EIC Detector Issues

Matthew A. C. Lamont
Brookhaven National Lab

work in conjunction with Elke Aschenauer, Pavel Nevski (BNL), Anders Kirleis and Will Foreman (sophomores at SUNY-SB)

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Detector requirements from physics

- e+p physics
  - ➡ Need the same detector for inclusive (ep → e'X), semi-inclusive (ep → e'X + hadrons) and exclusive (ep → e'p+π) reactions
    - Need to have a large acceptance (*both* mid- and forward-rapidity)
    - Crucial to have particle identification
      - e, π, K, p, n over wide momentum range and scattering angles
      - Excellent secondary vertex resolution (charm)
    - Small systematic uncertainty for e/p polarisation measurements
    - Small systematic uncertainty for luminosity measurements
- e+A physics
  - ➡ Most requirements similar to e+p guidelines
  - ➡ Additional complication arises from the need to tag the struck nucleus in exclusive and diffractive reactions
- Also, important to have the same detector for all energies
  - ➡ Reduce systematic errors

Simulations

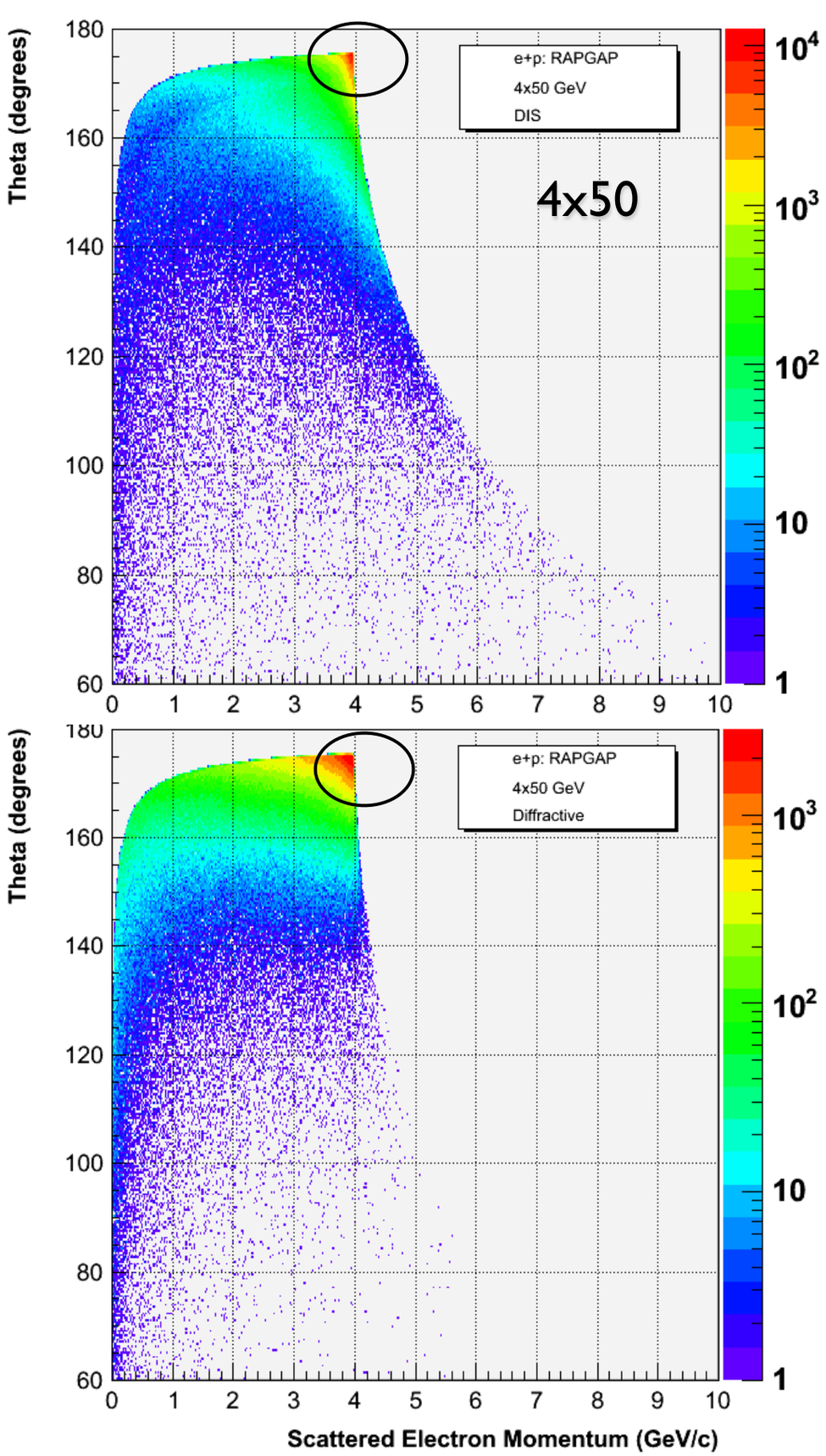
- Initial simulations performed using the RAPGAP simulation code in both DIS and diffractive mode
- No detector information involved in these simulations

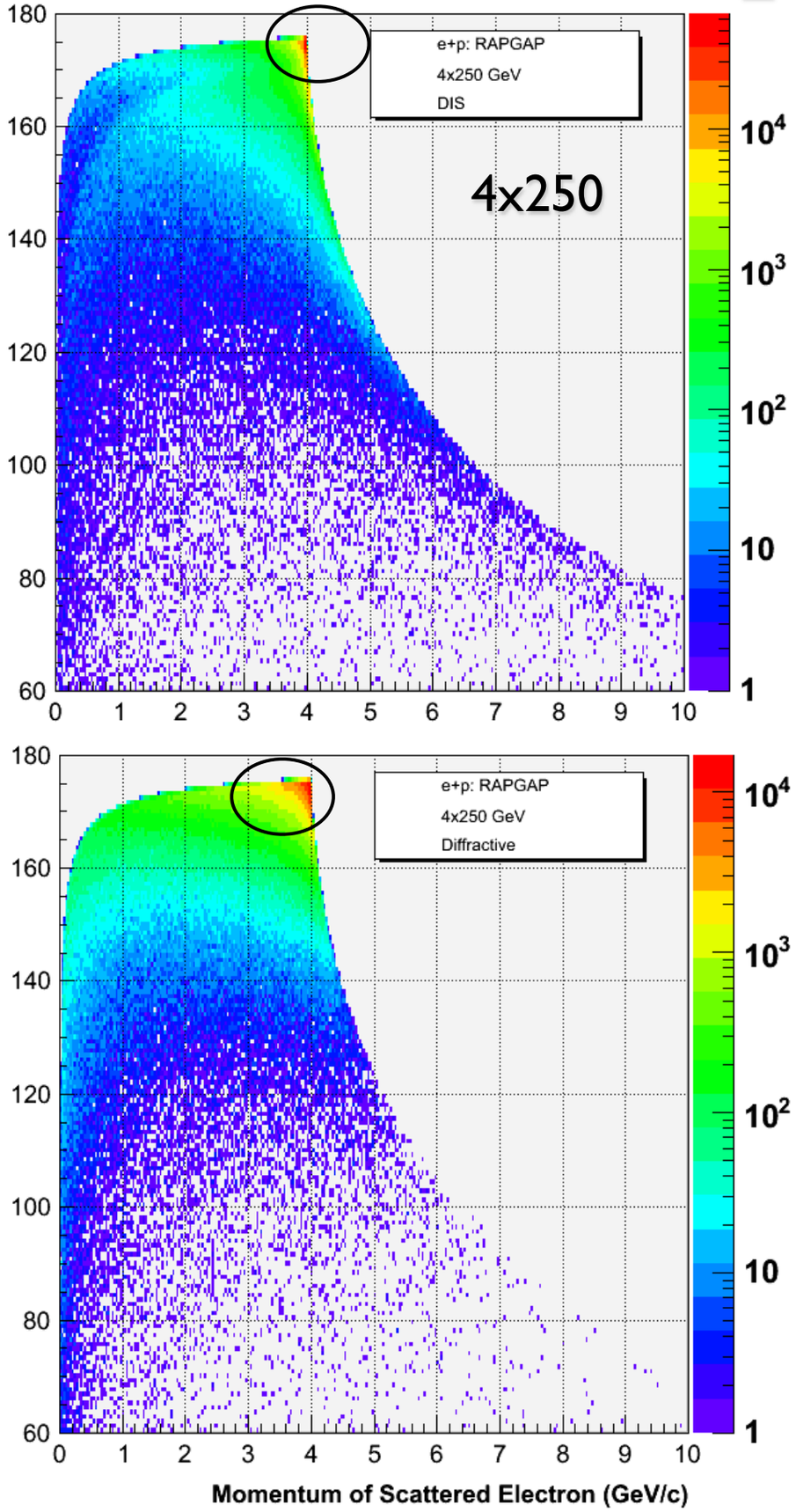
  ➡ importantly, no magnetic field
- Detector geometry implemented in Geant 3, code about ready to run simulations through and make trees out of them

  ➡ Also run PYTHIA with radiative corrections
- Anyone can apply for an EIC account at BNL and have access to the simulations

Event kinematics: scattered lepton

DIS





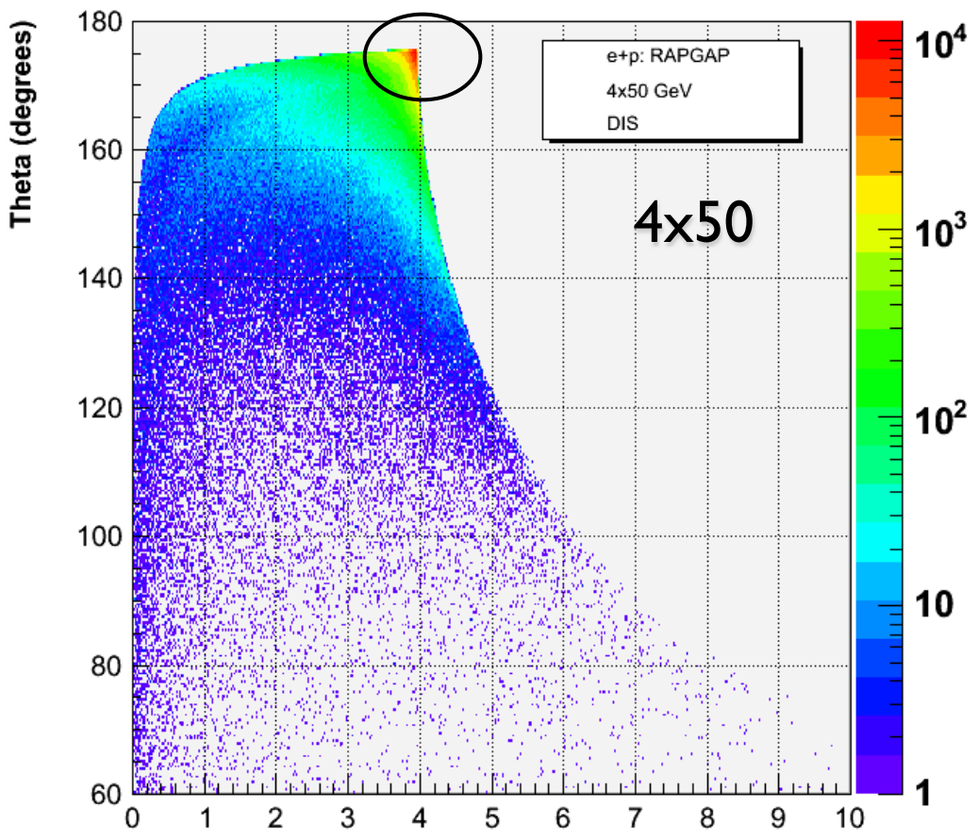
175°

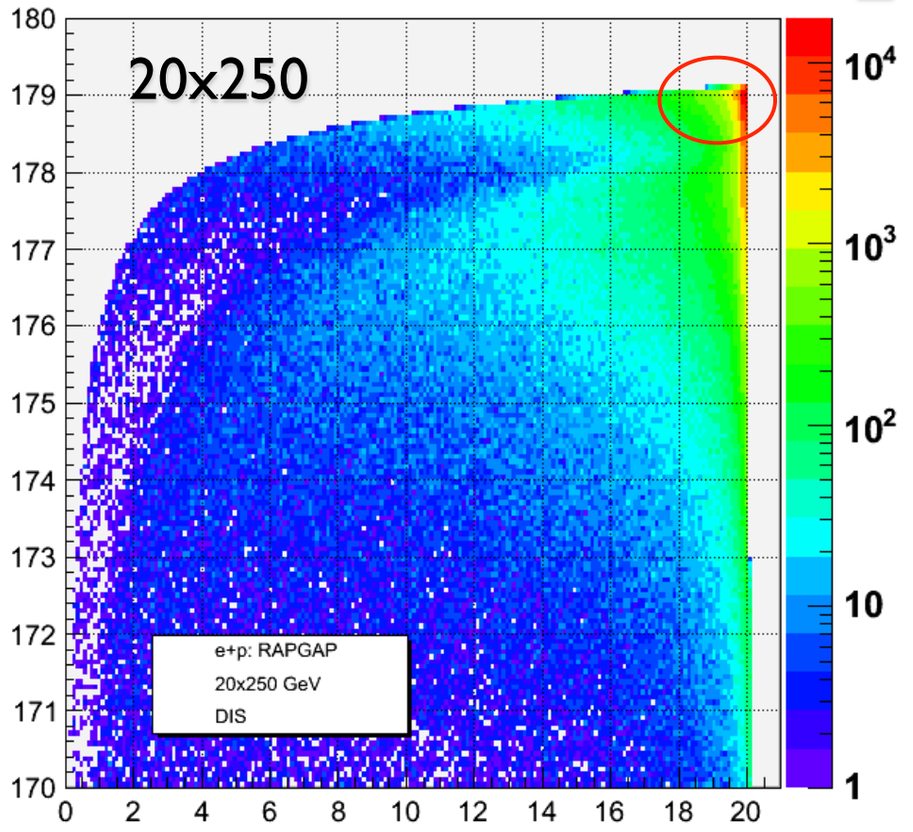
DIFFRACTIVE

BR
NATI

Event kinematics: scattered lepton

DIS

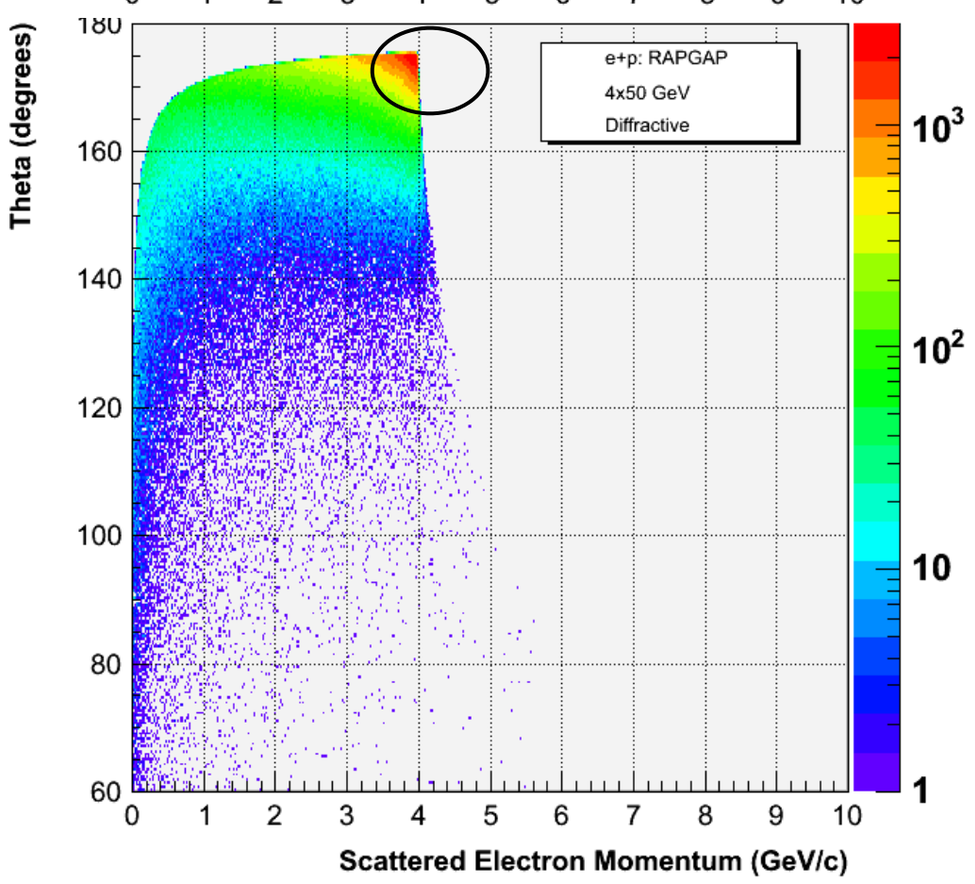


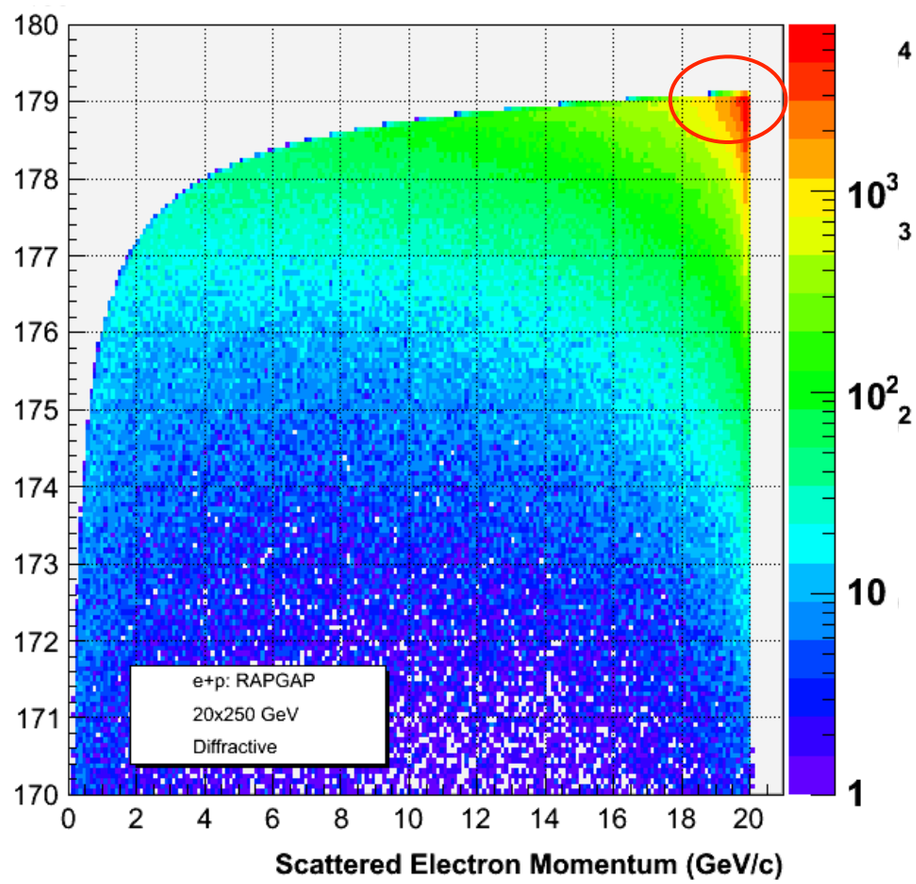


175°

179°

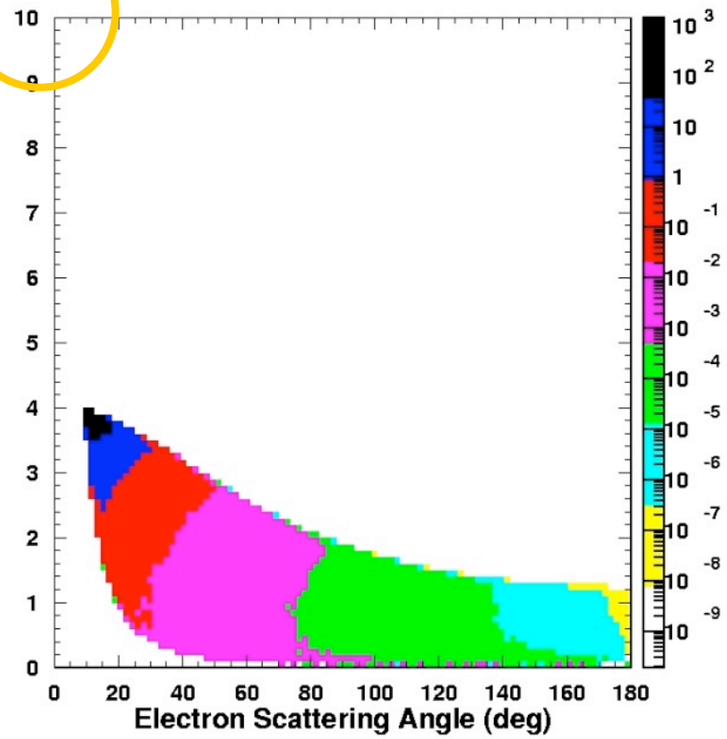
DIFFRACTIVE



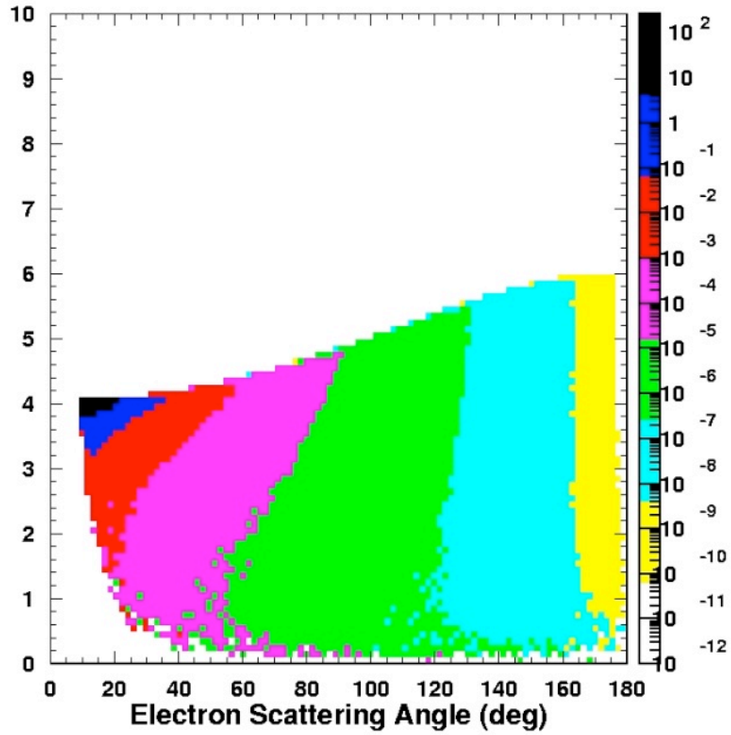


Event kinematics: scattered lepton

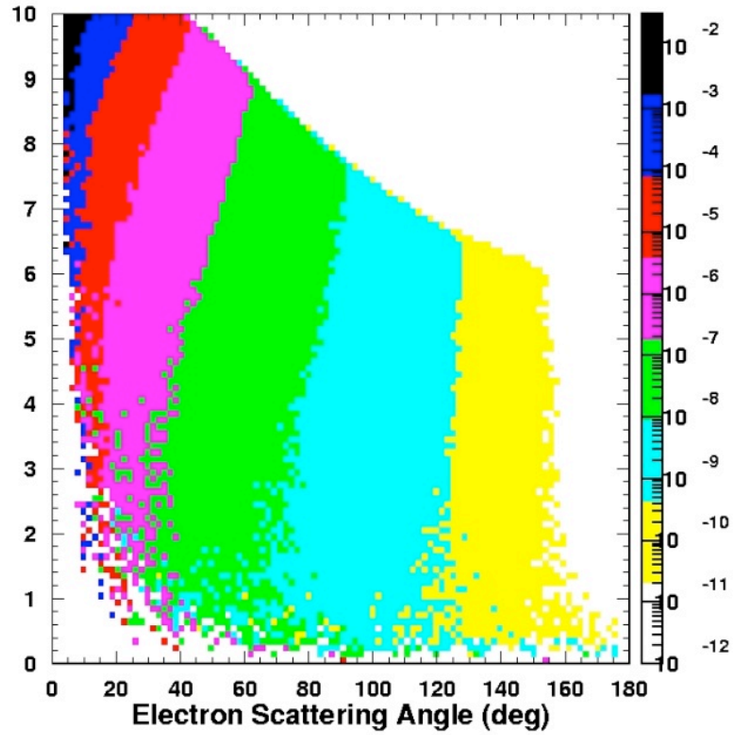
4 on 12



4 on 60

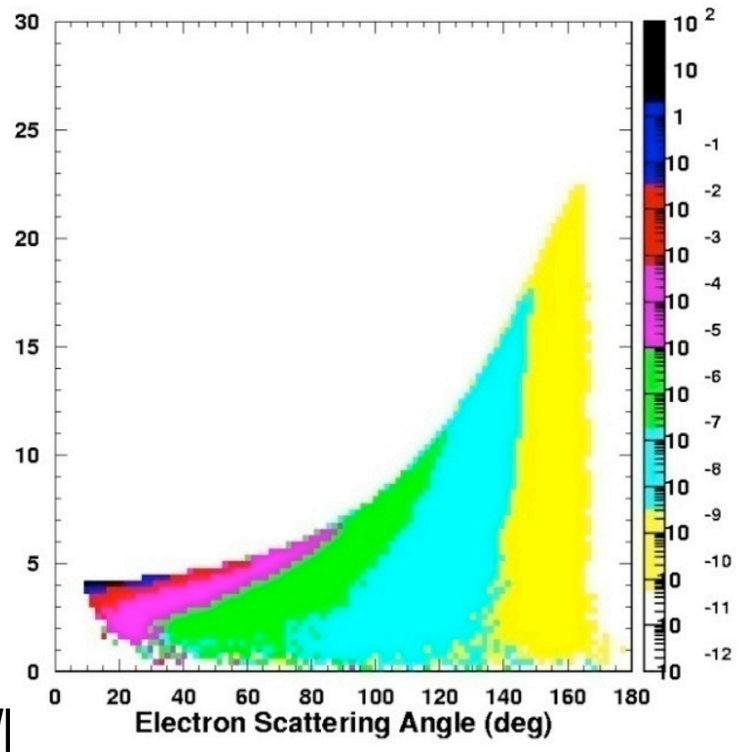


11 on 60

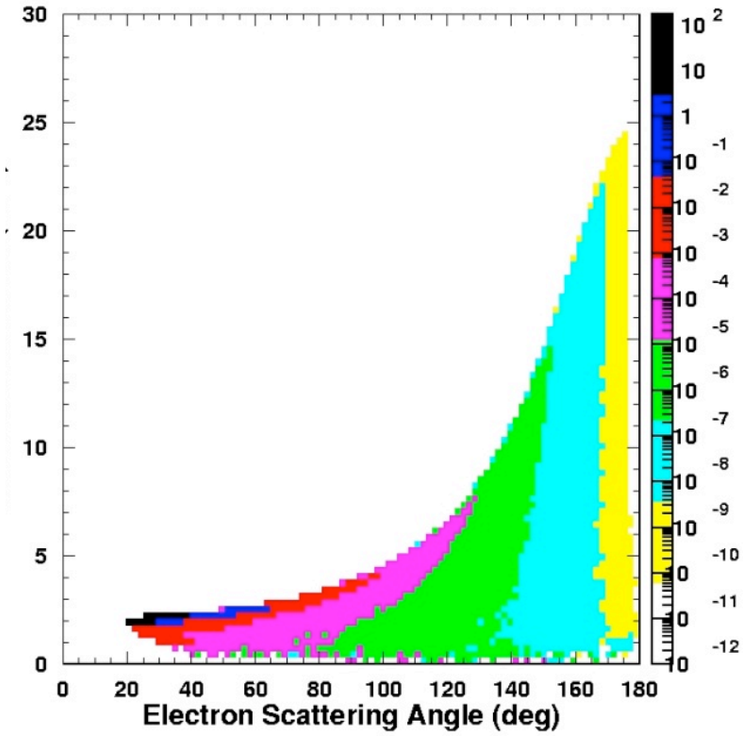


(Tanja Horn)

4 on 250



2 on 250



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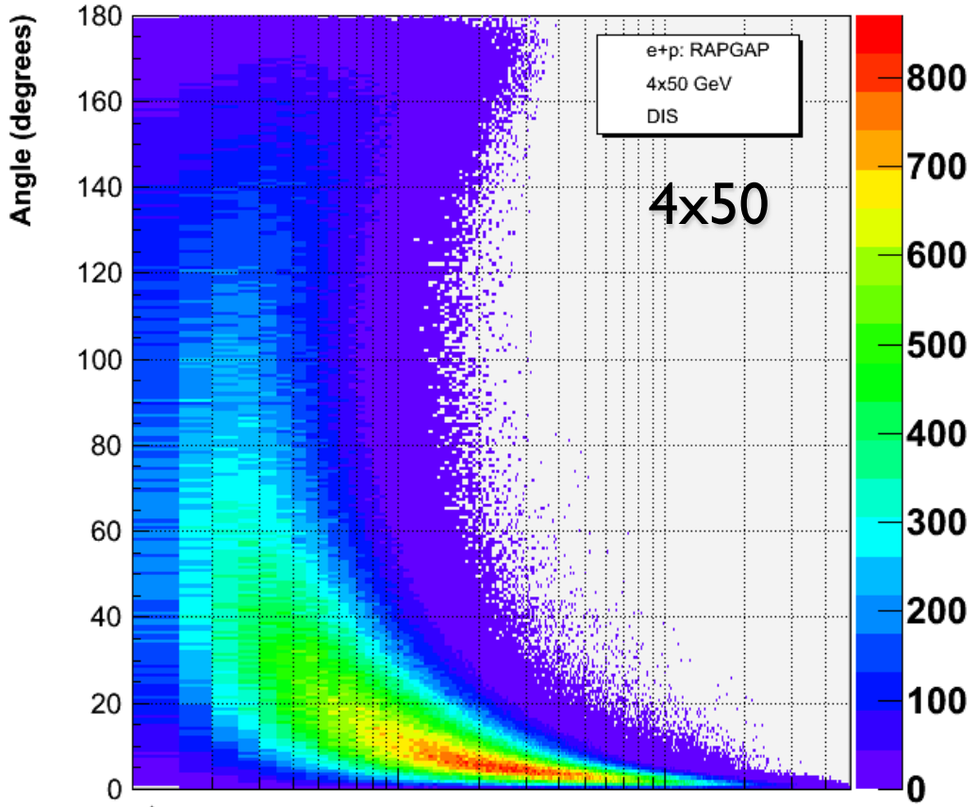
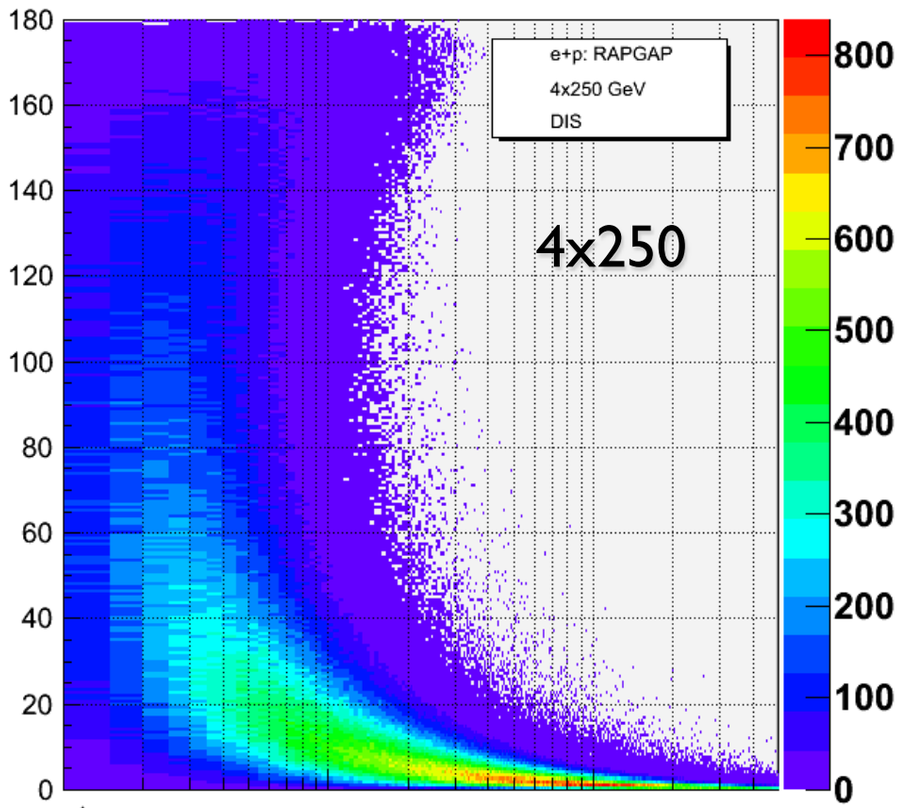
Event kinematics: produced hadrons (π^+)

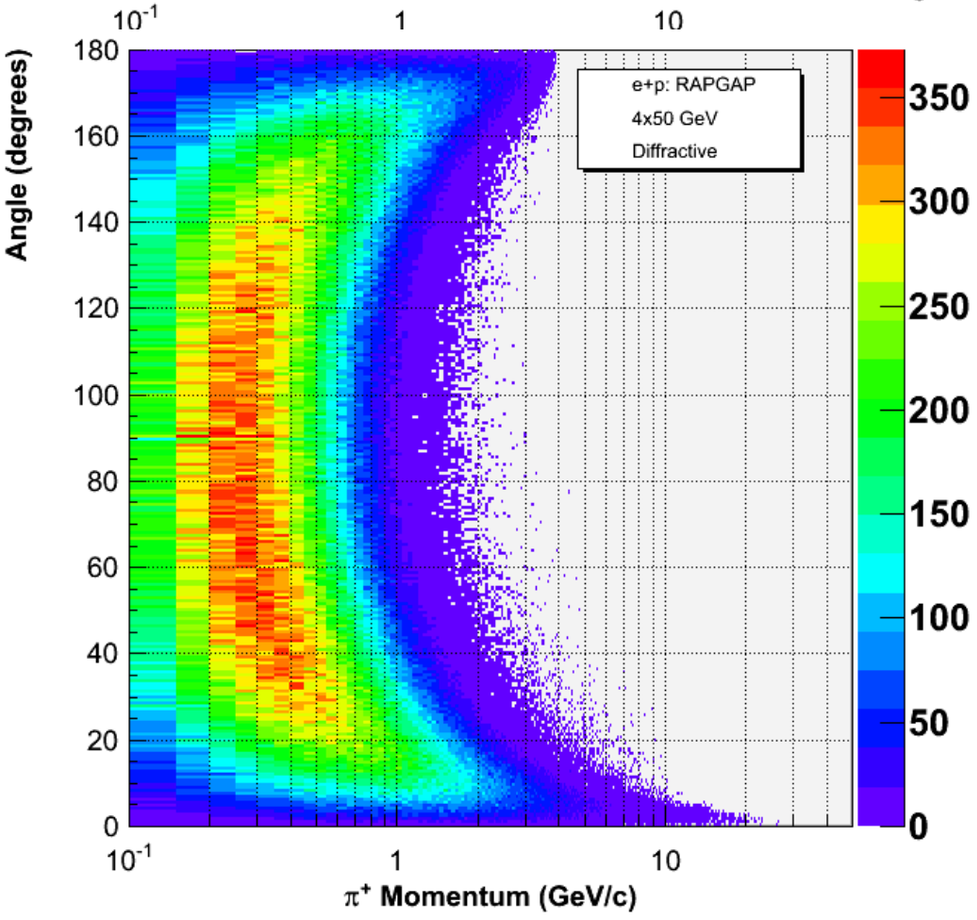
DIS

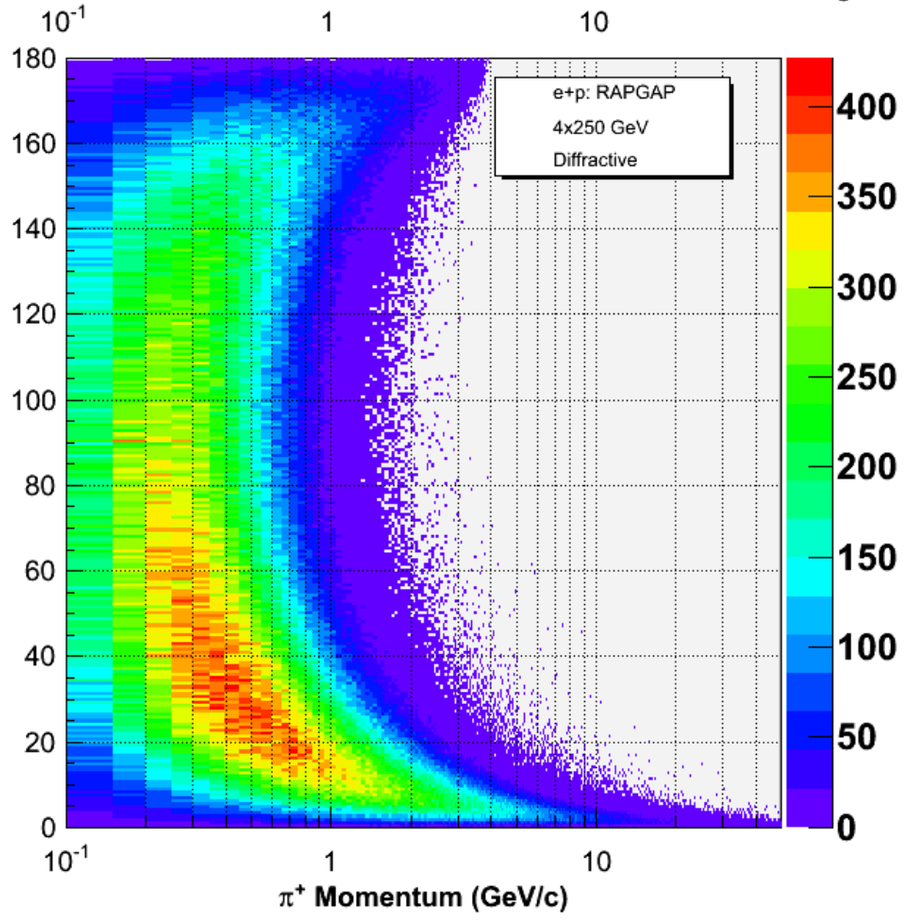




DIS:
small
theta
important

DIFFRACTIVE





BNAT

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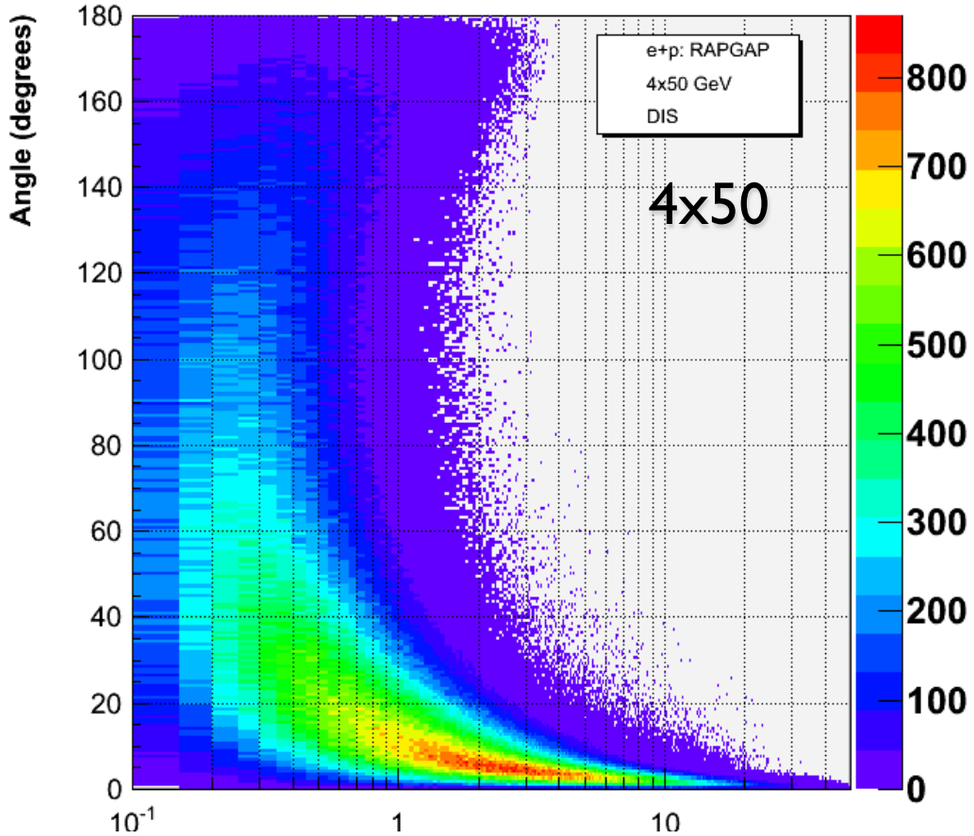

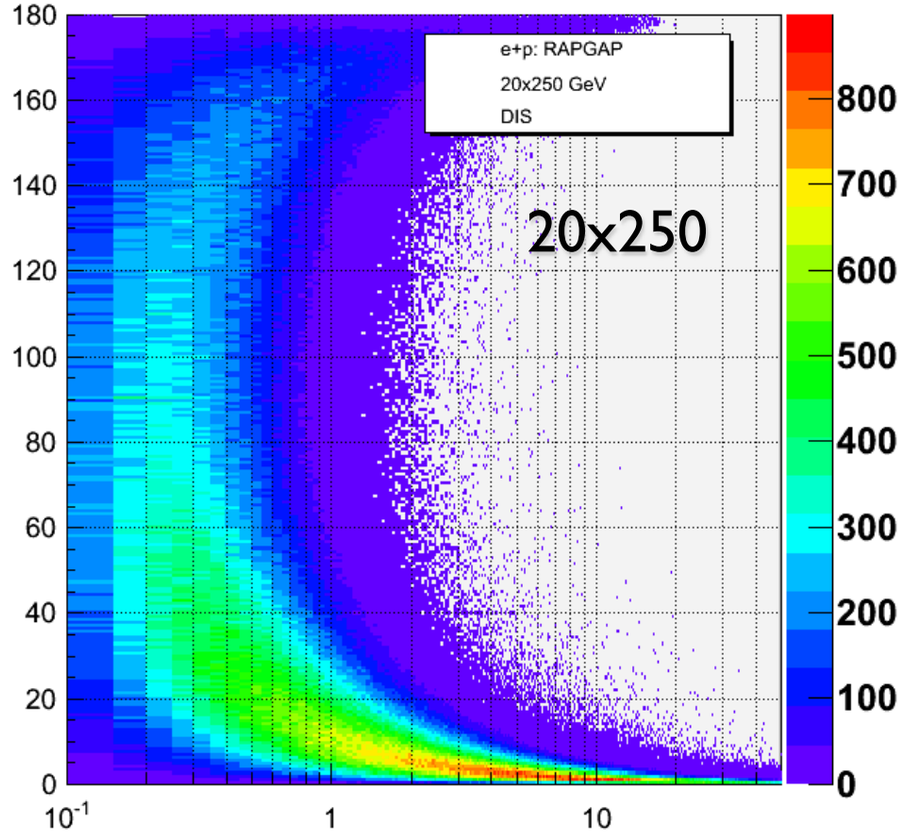

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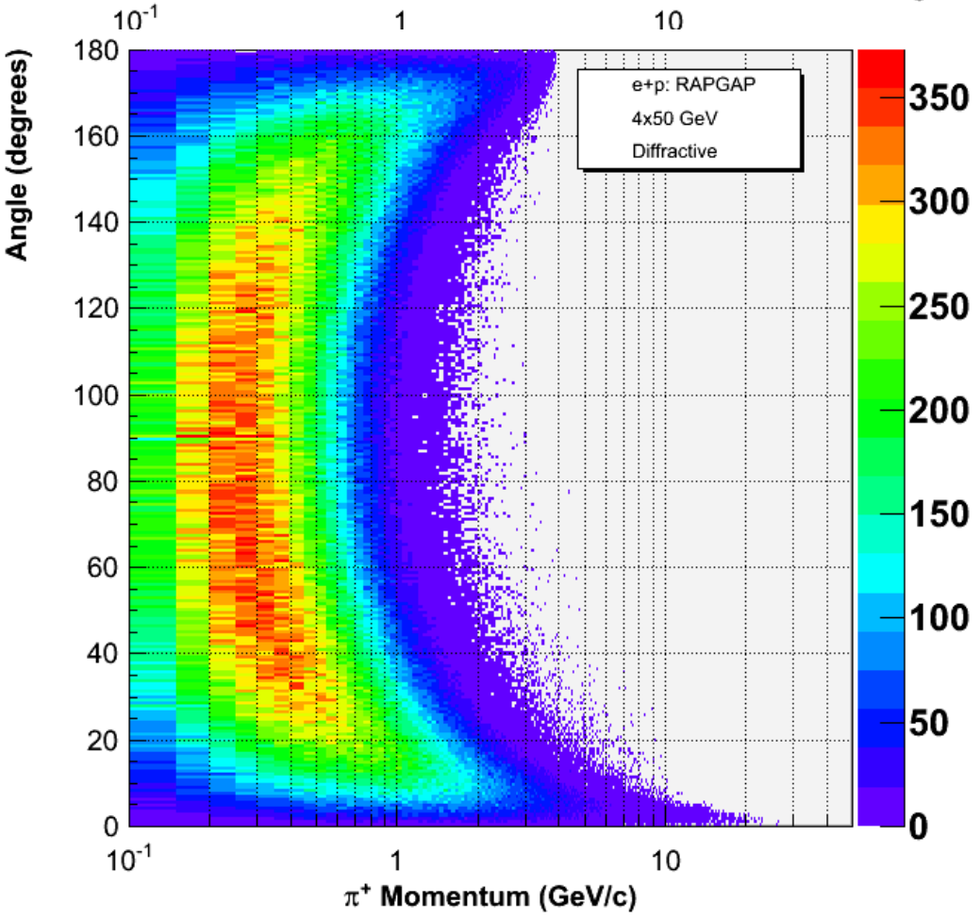
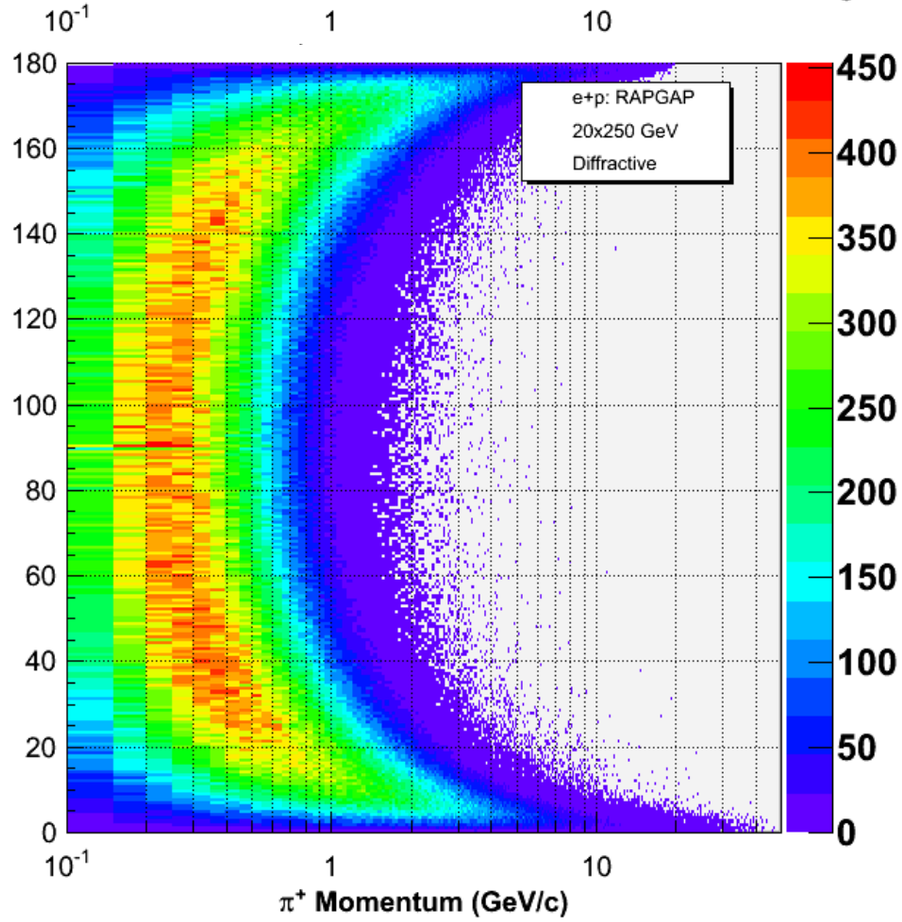
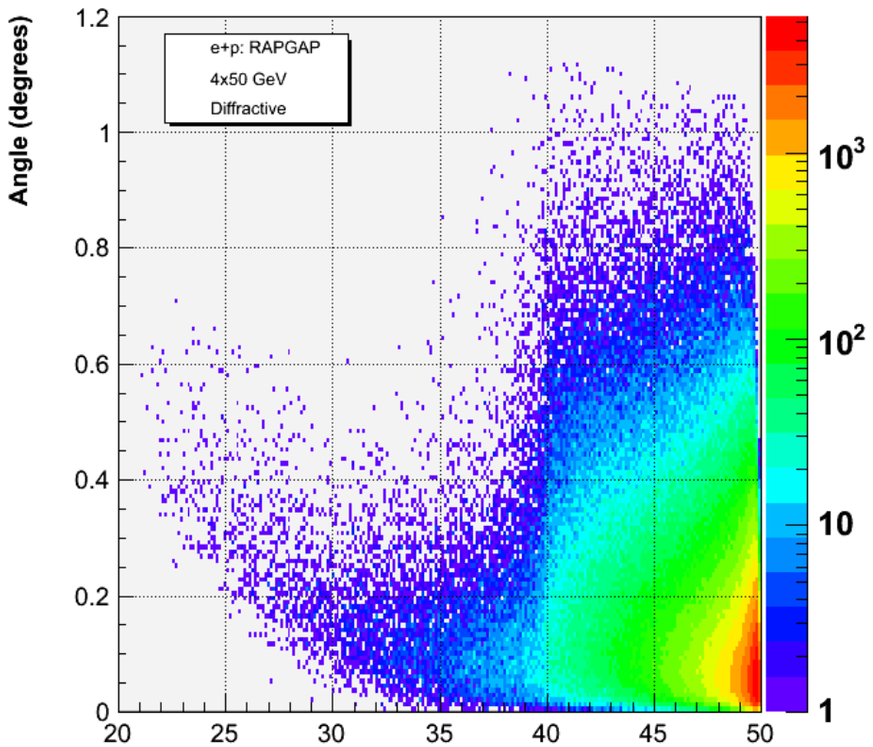




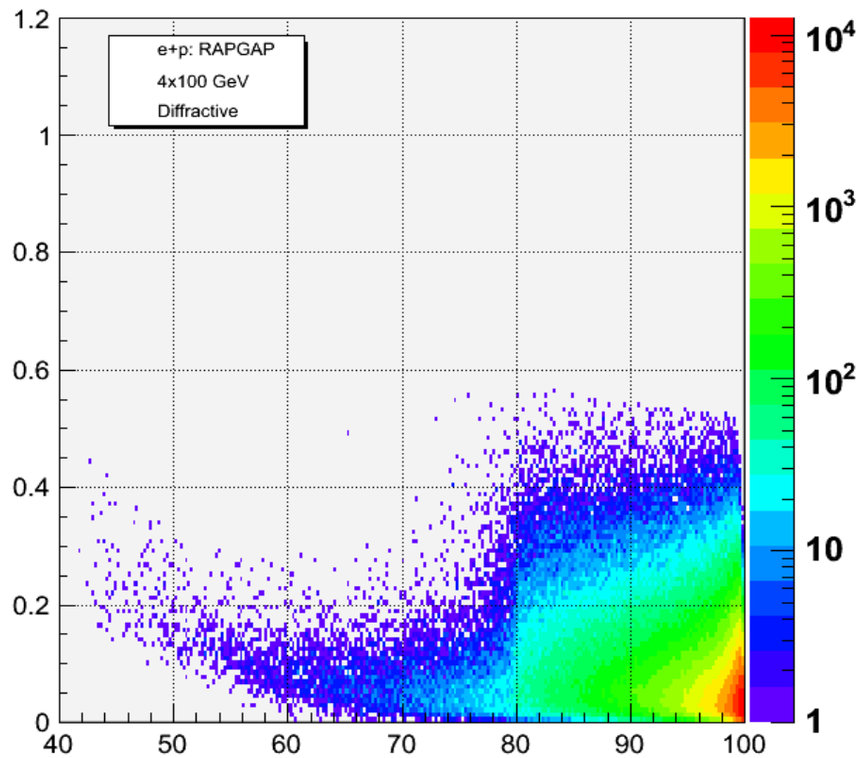
BNAT

Event kinematics: scattered proton (diffractive)

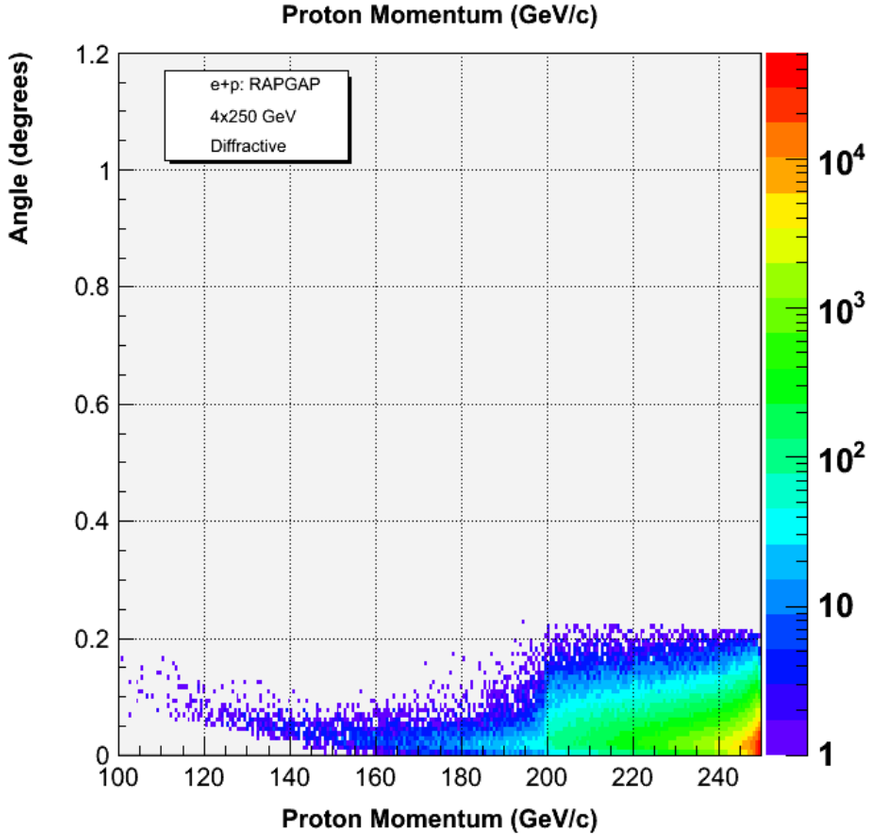
4x50



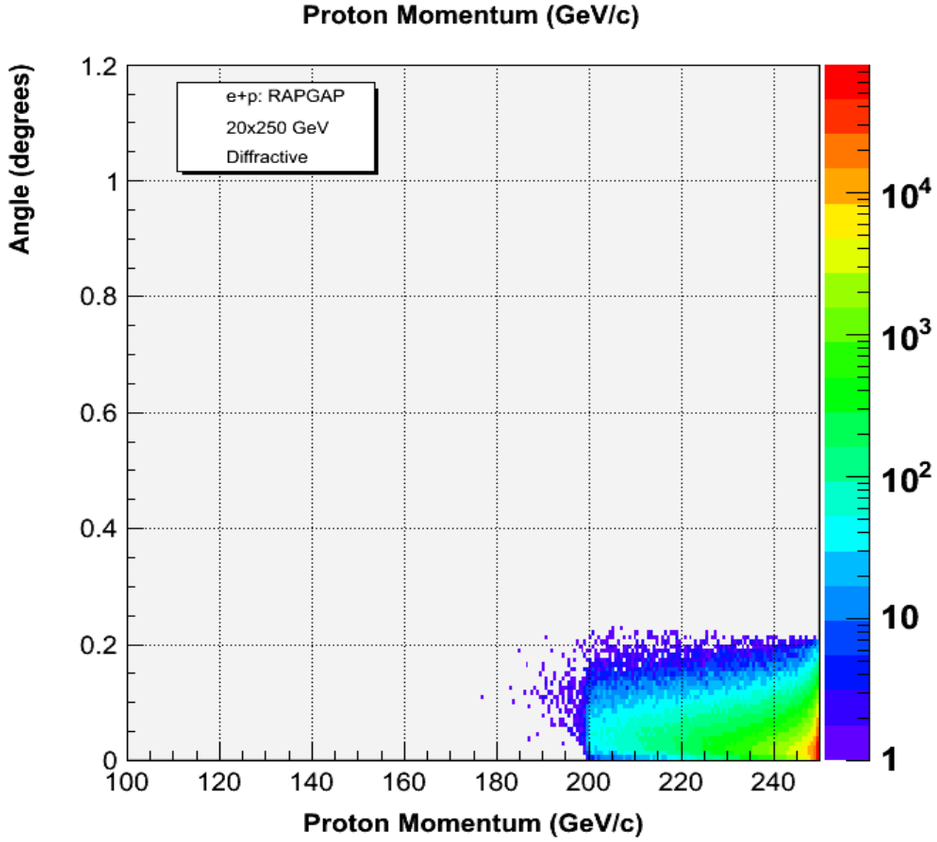
4x100



4x250



20x250



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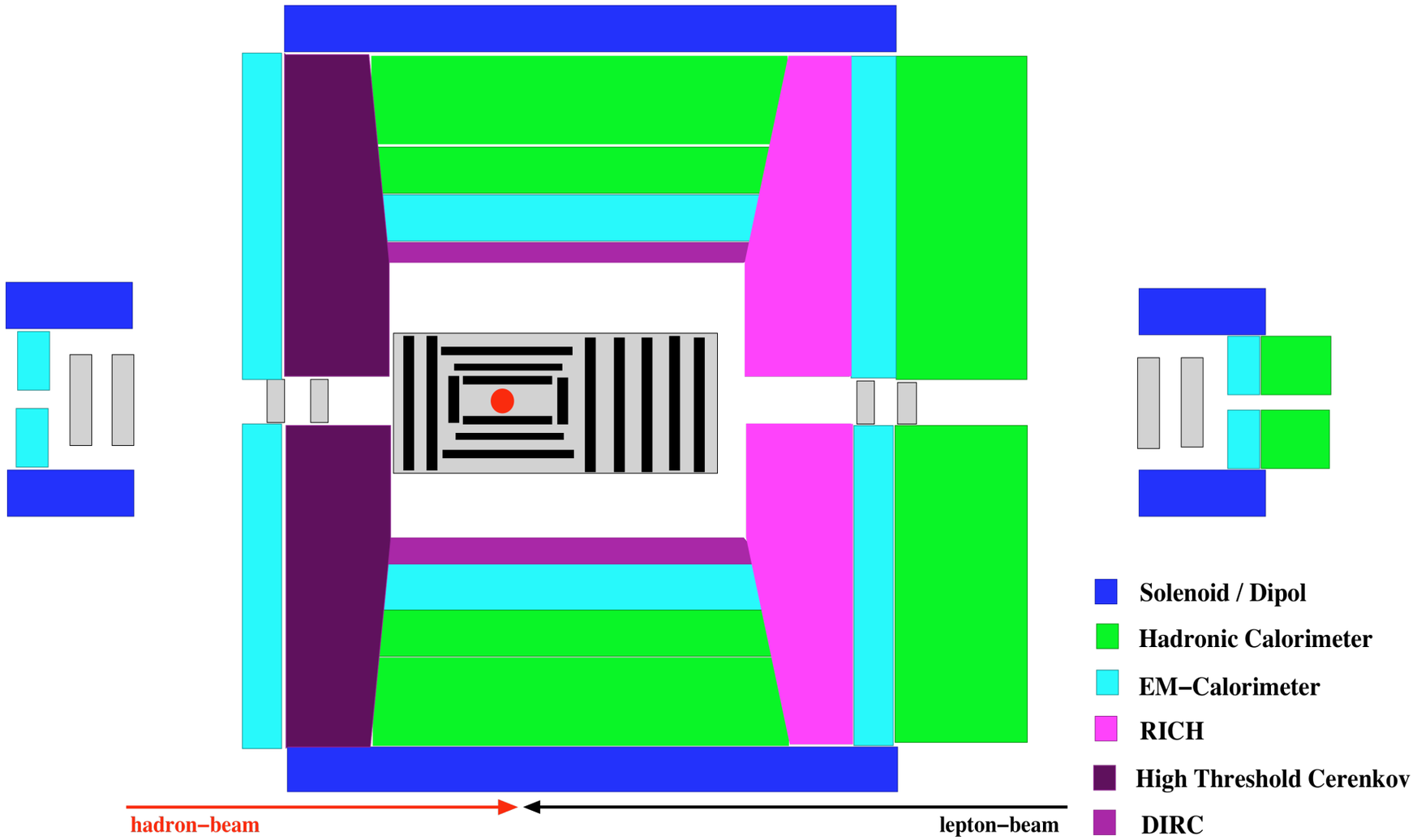
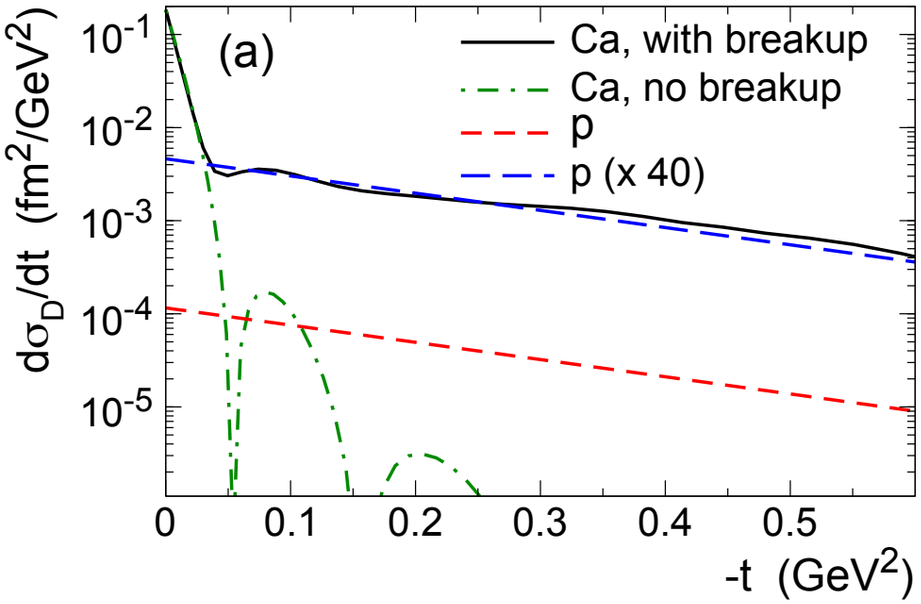
First attempt at detector design

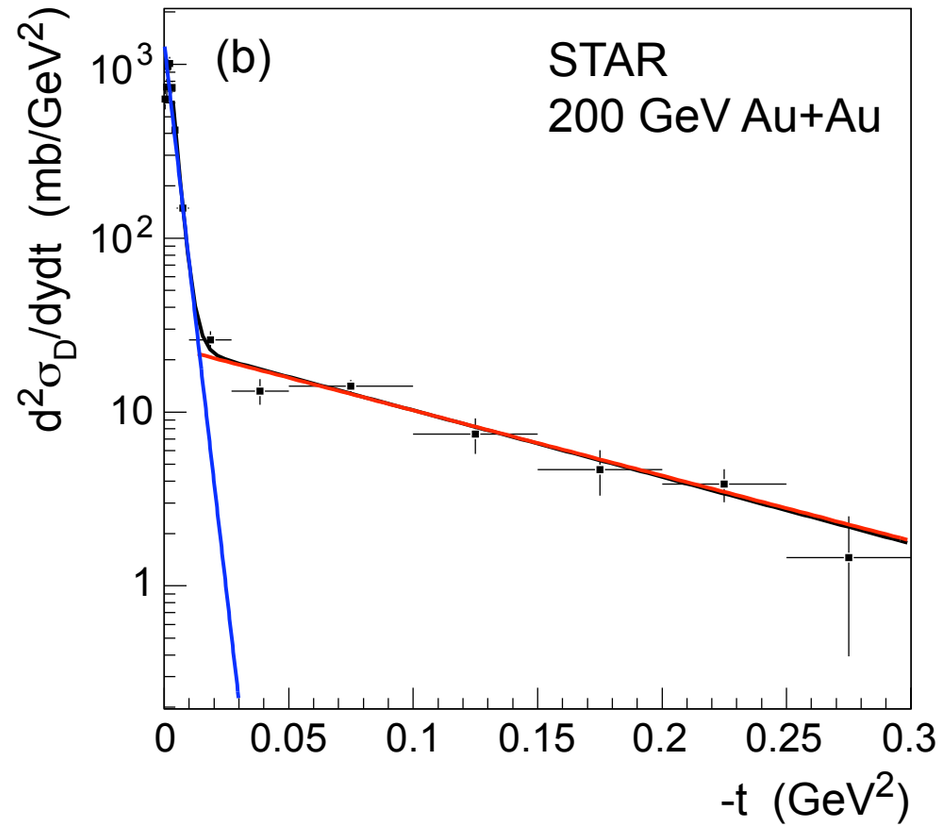


- Dipoles need to have good forward momentum resolution
  - ➡ Solenoid has no magnetic field for r → 0
- RICH, DIRC for hadron pid
- High threshold Cherenkov → fast trigger for scattered lepton
- Radiation length very critical → low lepton energies

How to measure coherent diffraction in e+A ?

$$\frac{d\sigma}{dt}|_{t=0}(\gamma^* A \to V A) \propto \alpha_s^2 [G_A(x, Q^2)]^2$$





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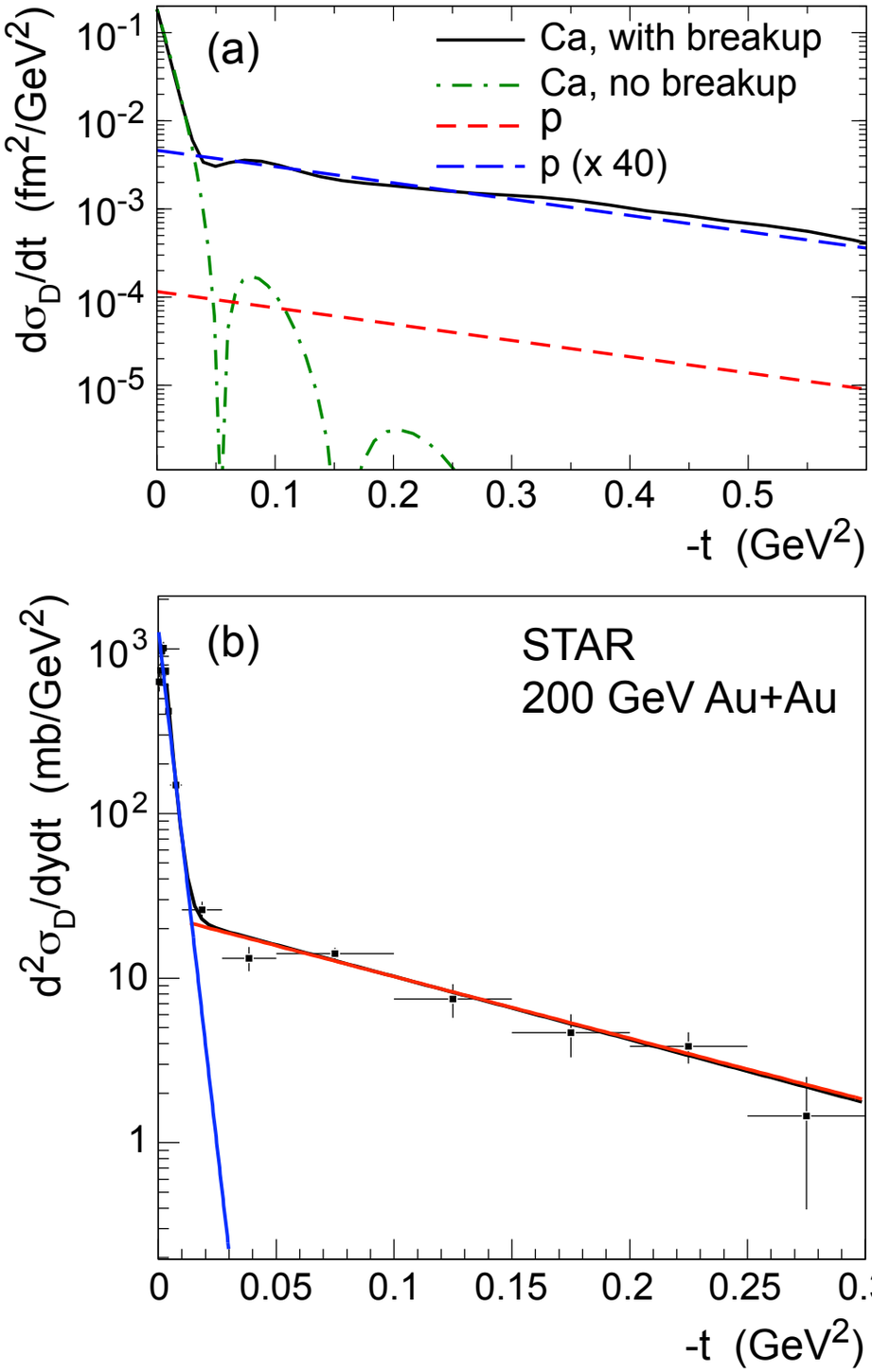

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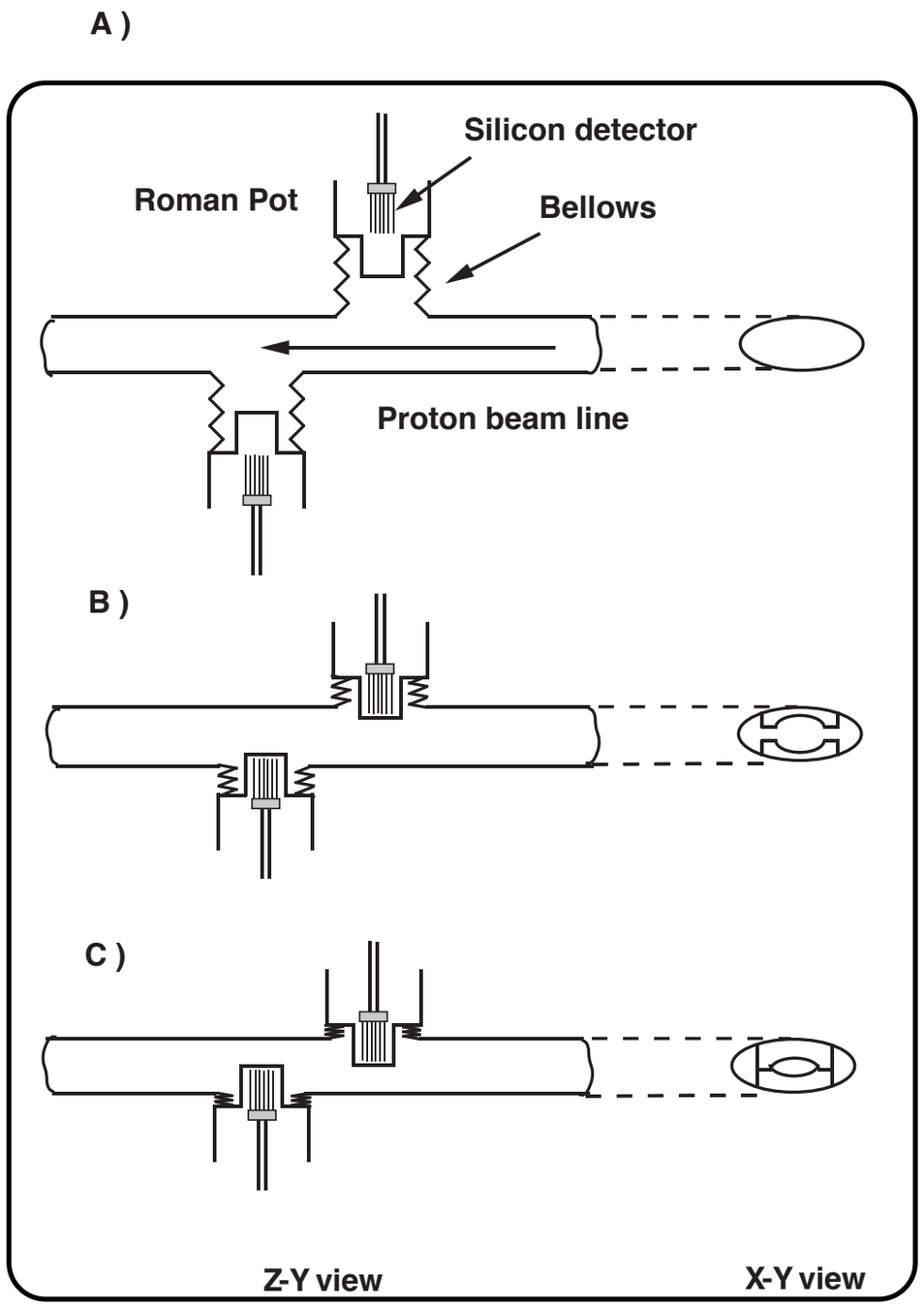

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  ➡ $p_T^{min} \sim pA\theta_{min}$

  - For beam energies = 100 GeV/n and θ_{min} = 0.08 mrad:

species (A)	p_T^{min} (GeV/c)
d (2)	0.02
Si (28)	0.22
Cu (64)	0.51
In (115)	0.92
Au (197)	1.58
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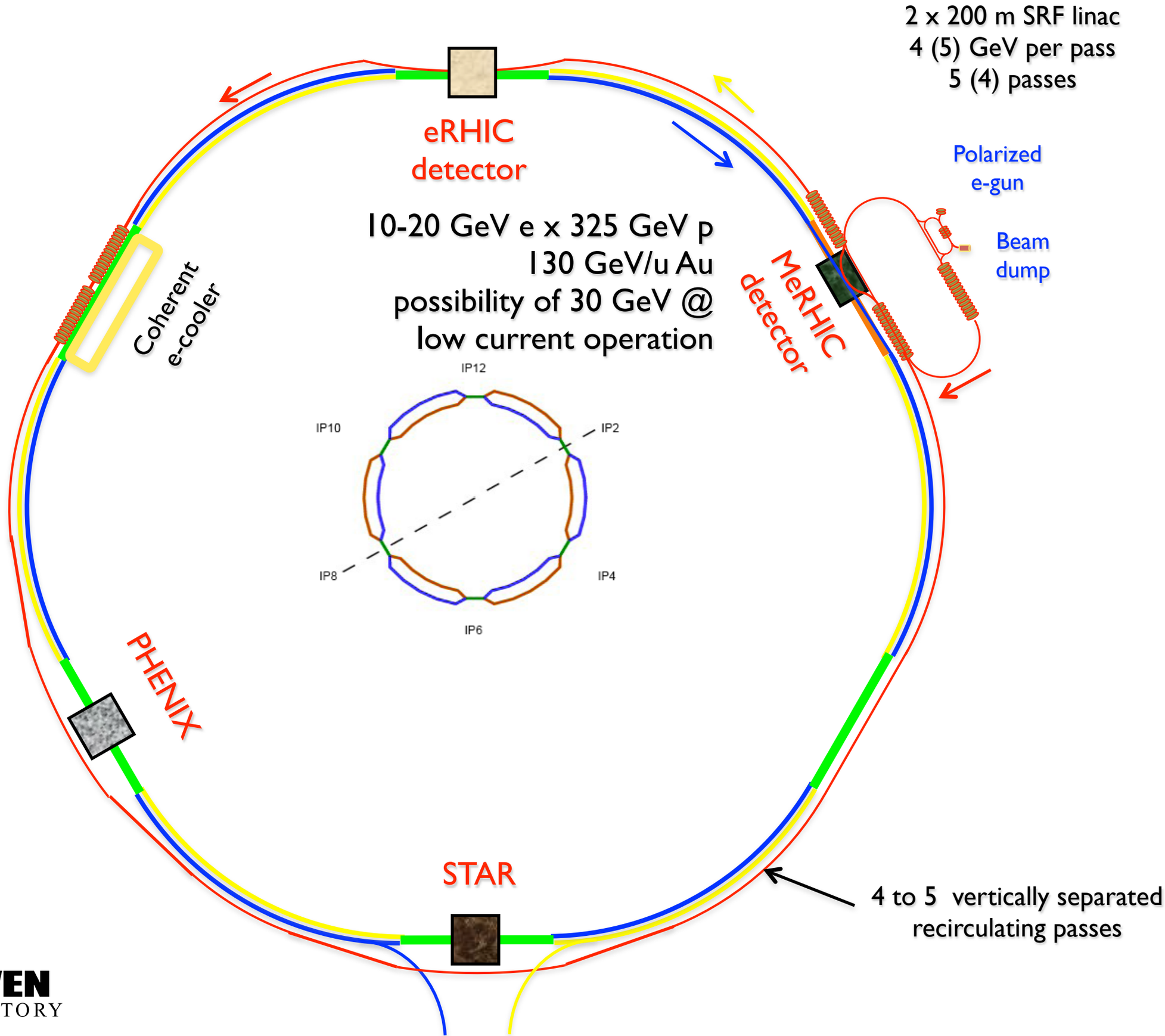
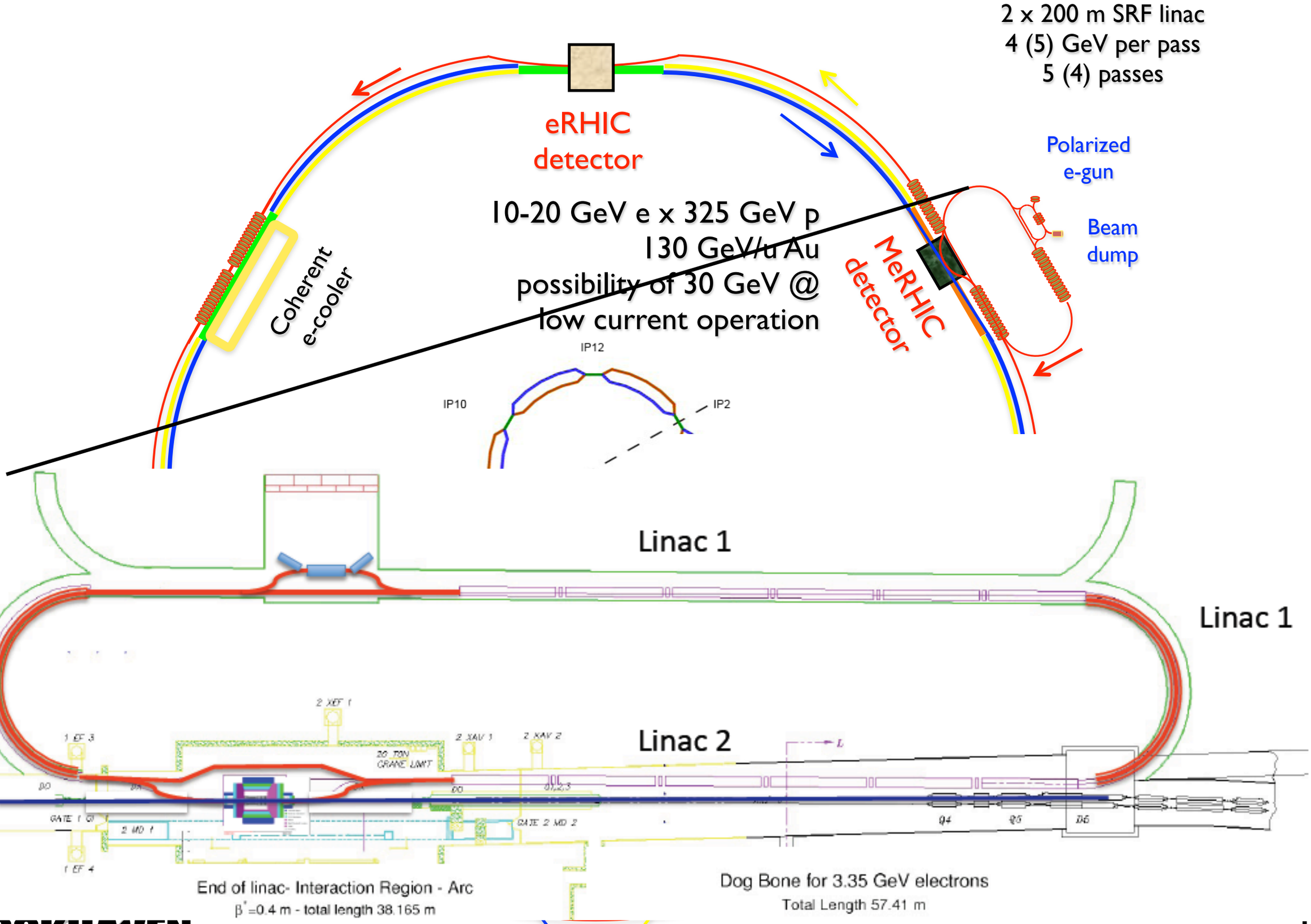
For large A, nucleus cannot be separated from beam without breaking up

Detector considerations: IR design

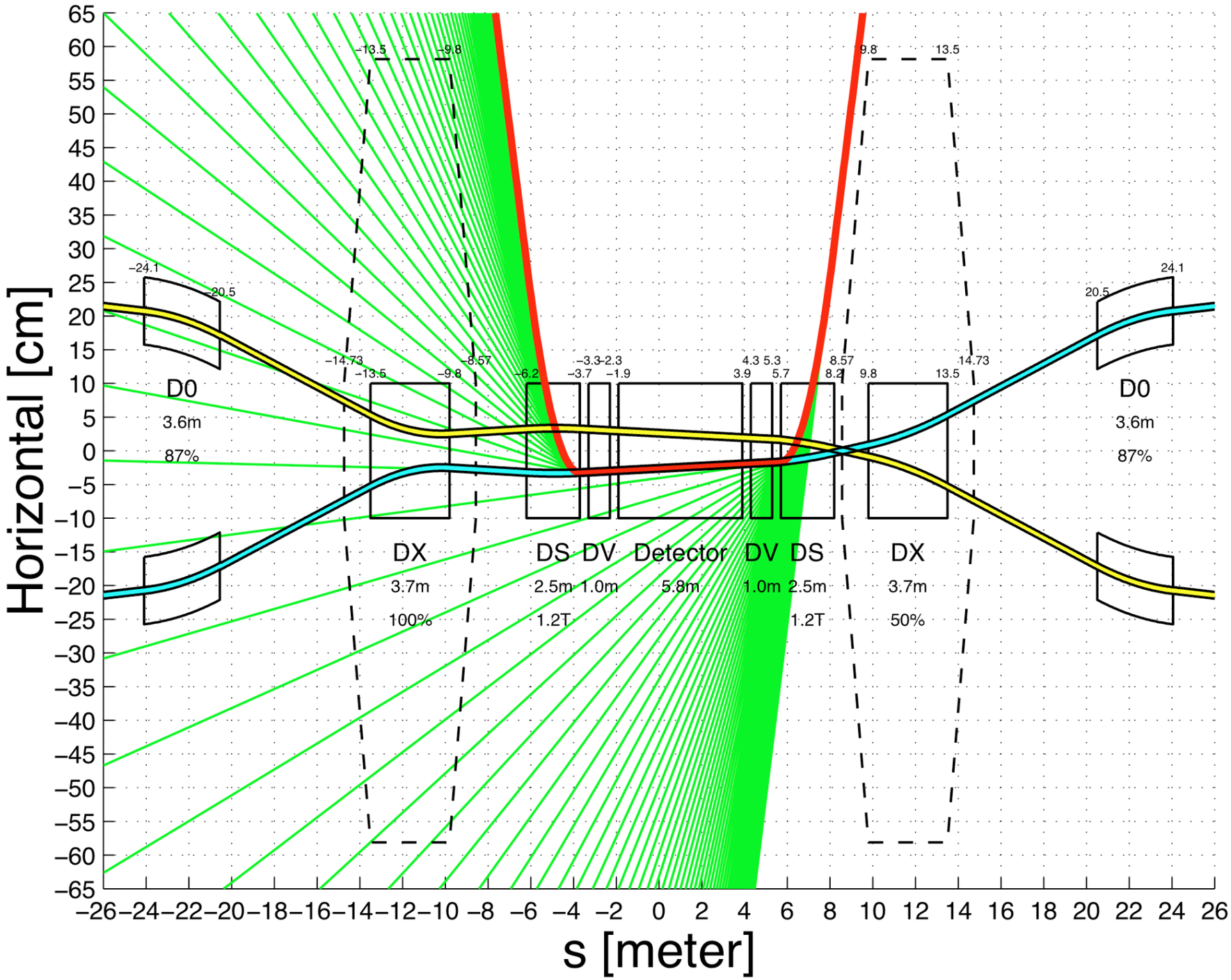


Detector considerations: IR design



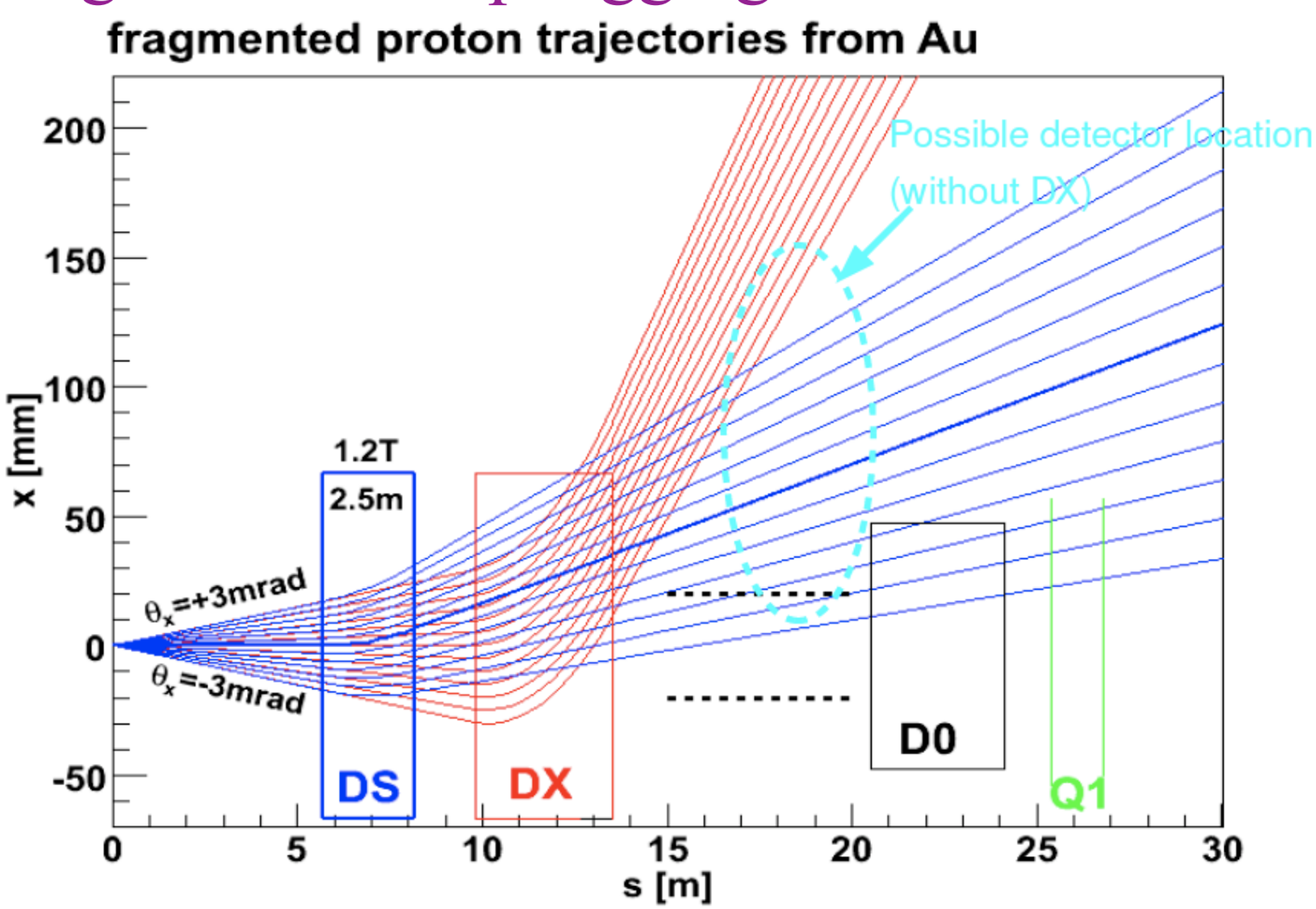
Preliminary IR Design for MeRHIC at IP2

- No synchrotron shielding included
- Height of beam from floor ~ 6 feet



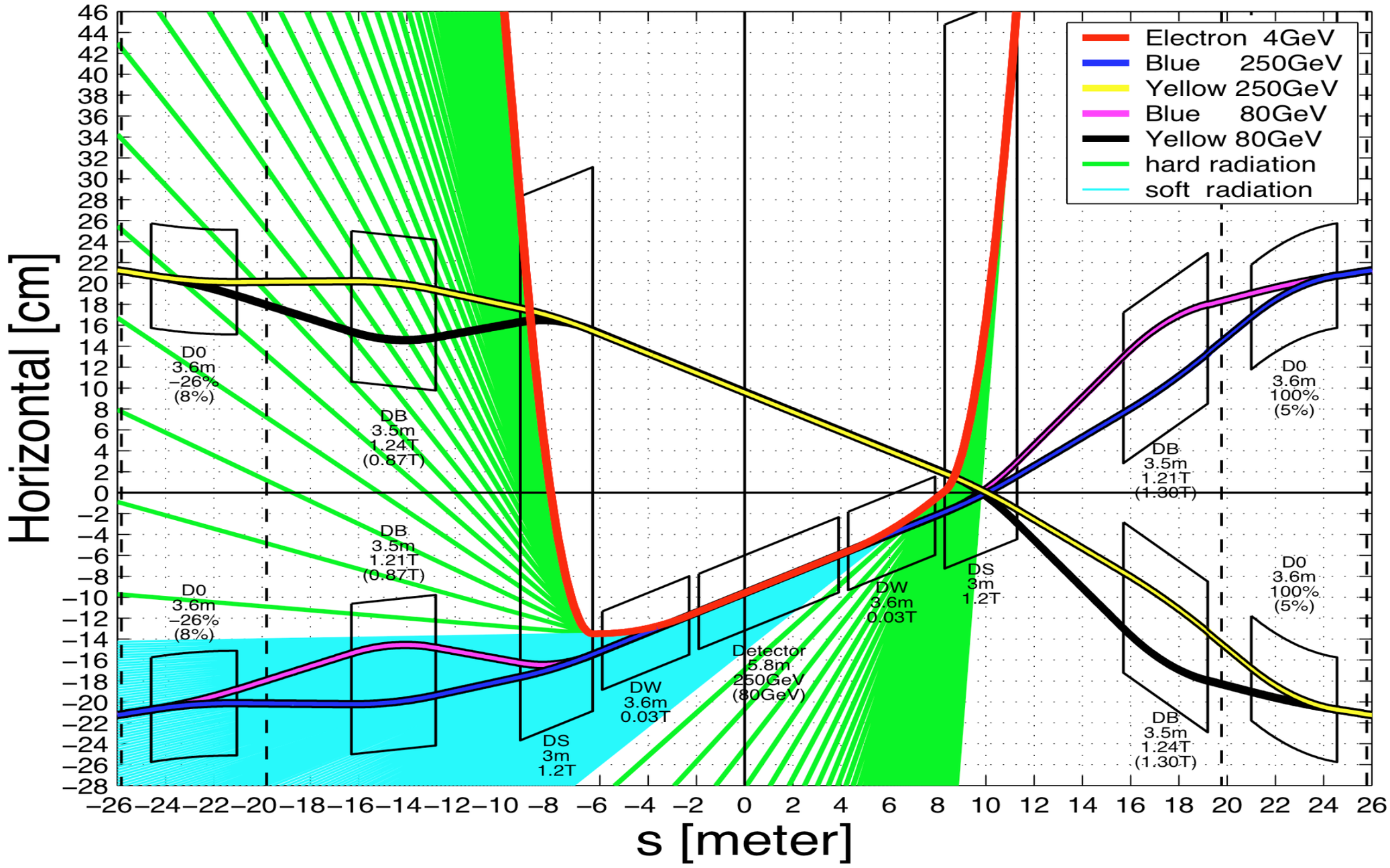
Detection from hadron beam fragments

- Tagging from Au fragments and p/n in e+p collisions
  - ➡ suppress incoherent scattering / ensure exclusivity
    - neutrons are detected in the Zero Degree Calorimeter
    - protons use magnetic rigidity (Au:p = 2.5:1)
  - ➡ DX magnet disturbs p tagging

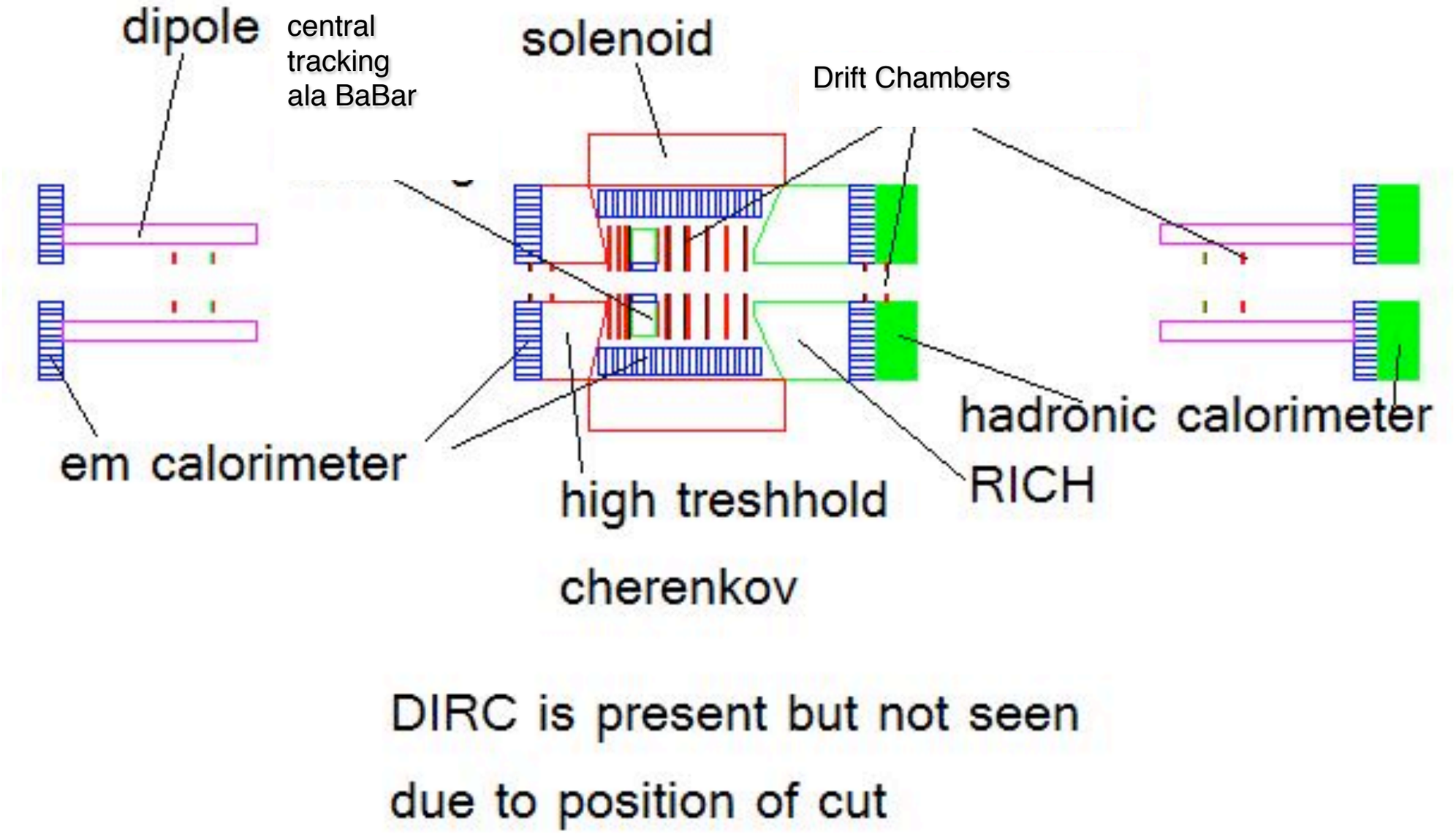


Latest IR Design for MeRHIC at IP2

- No synchrotron shielding included
- Height of beam from floor ~ 6 feet
- Allows p and A decay product tagging

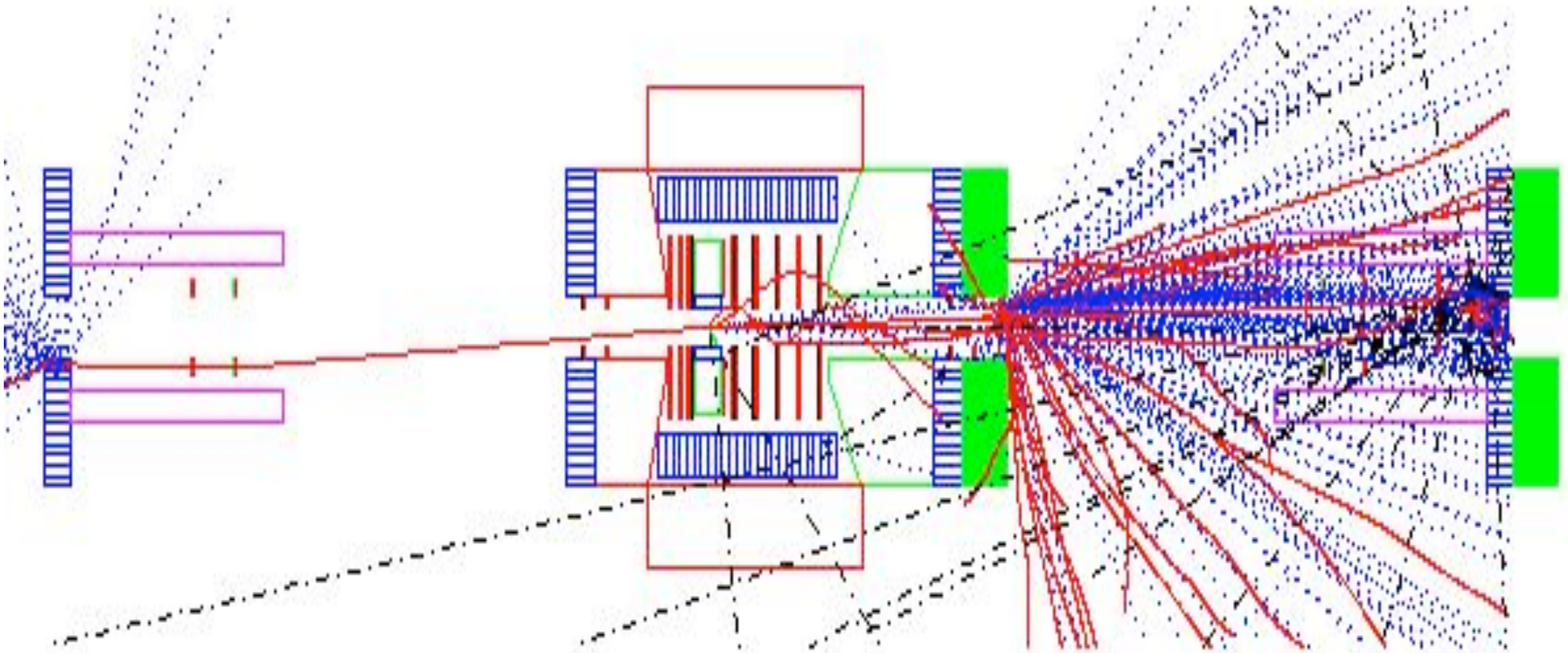


MeRHIC Detector in Geant 3



- Note - no hadronic barrel calorimeter due to height restrictions at IP2

MeRHIC Detector in Geant 3



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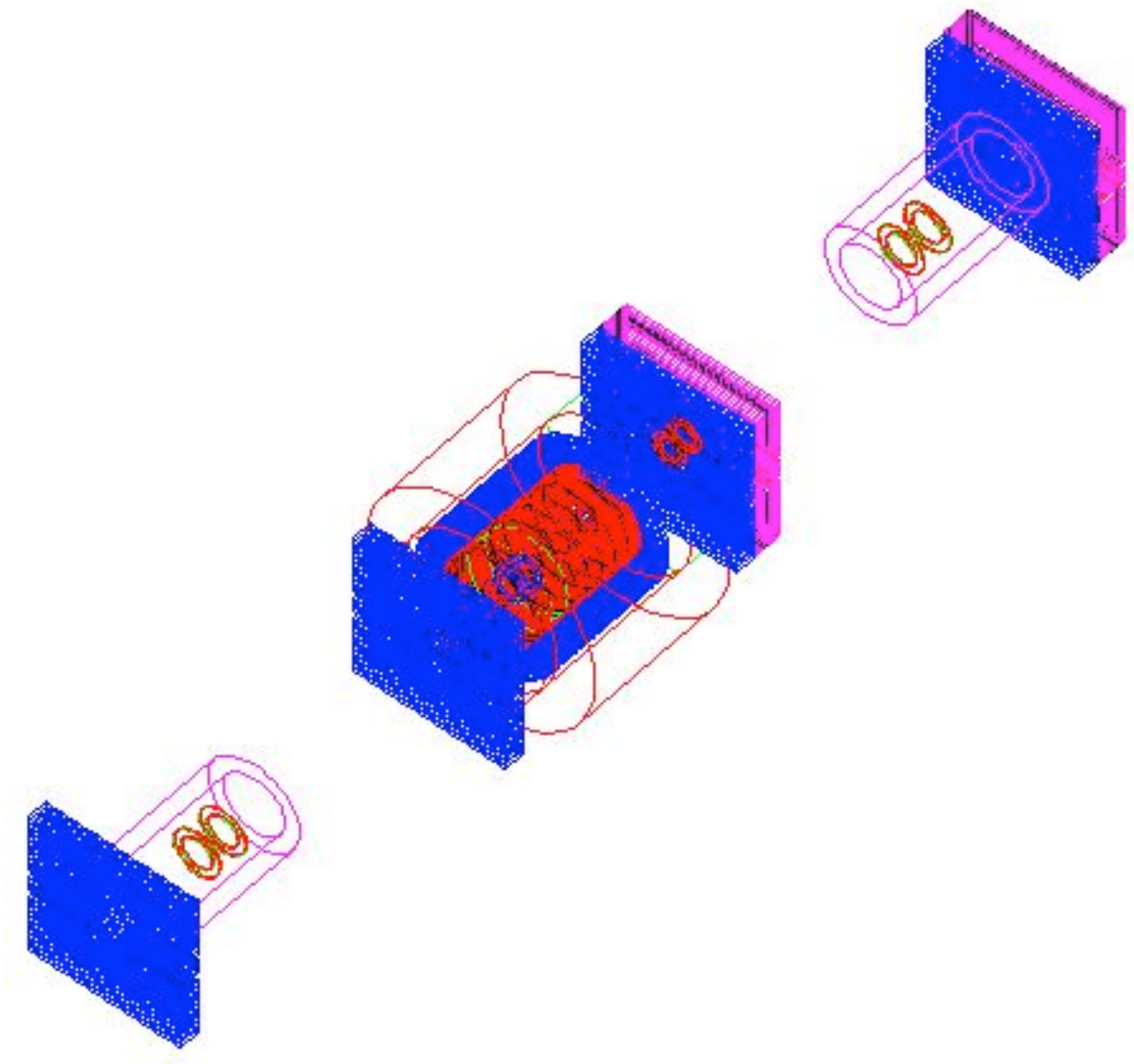

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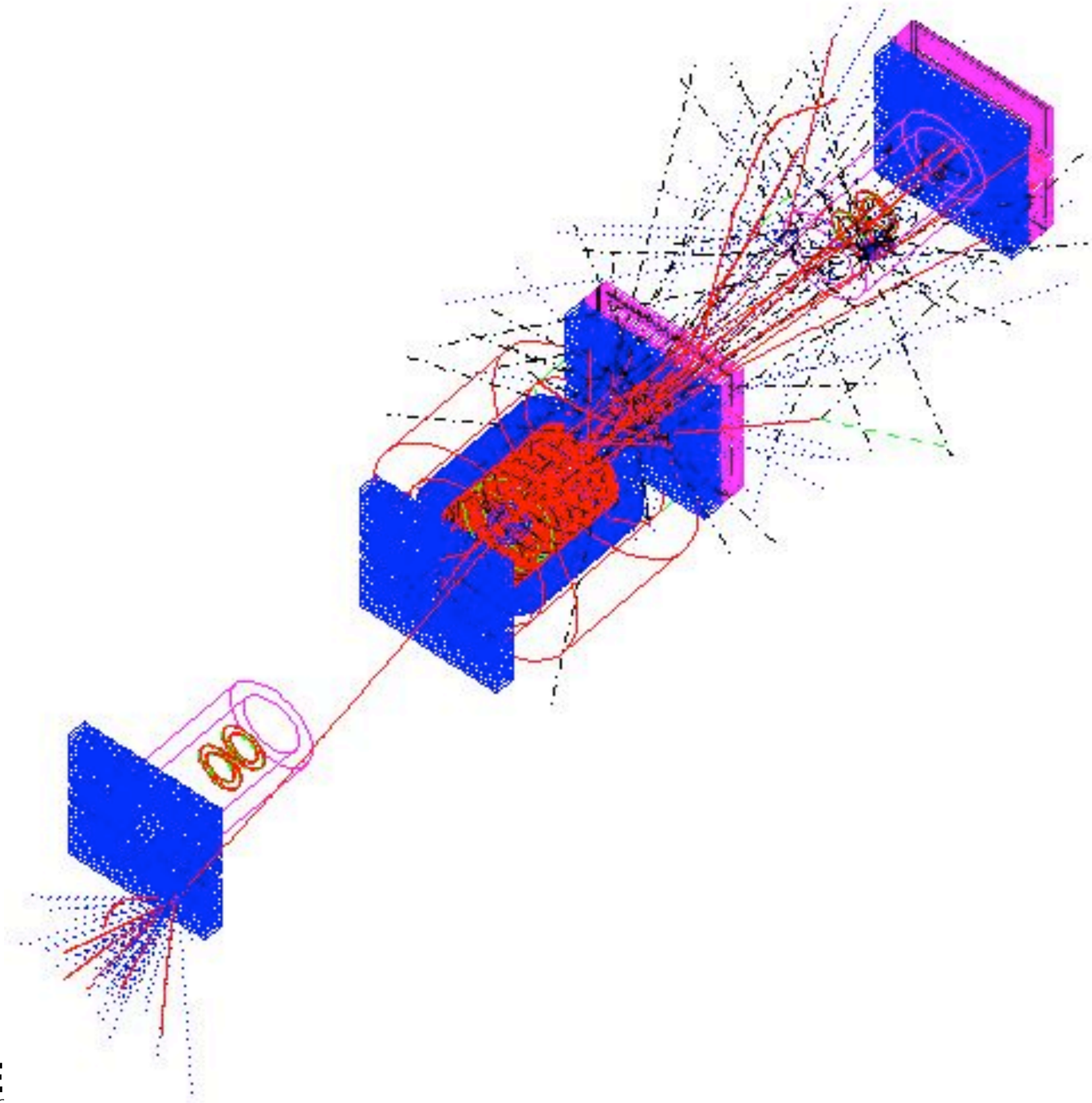

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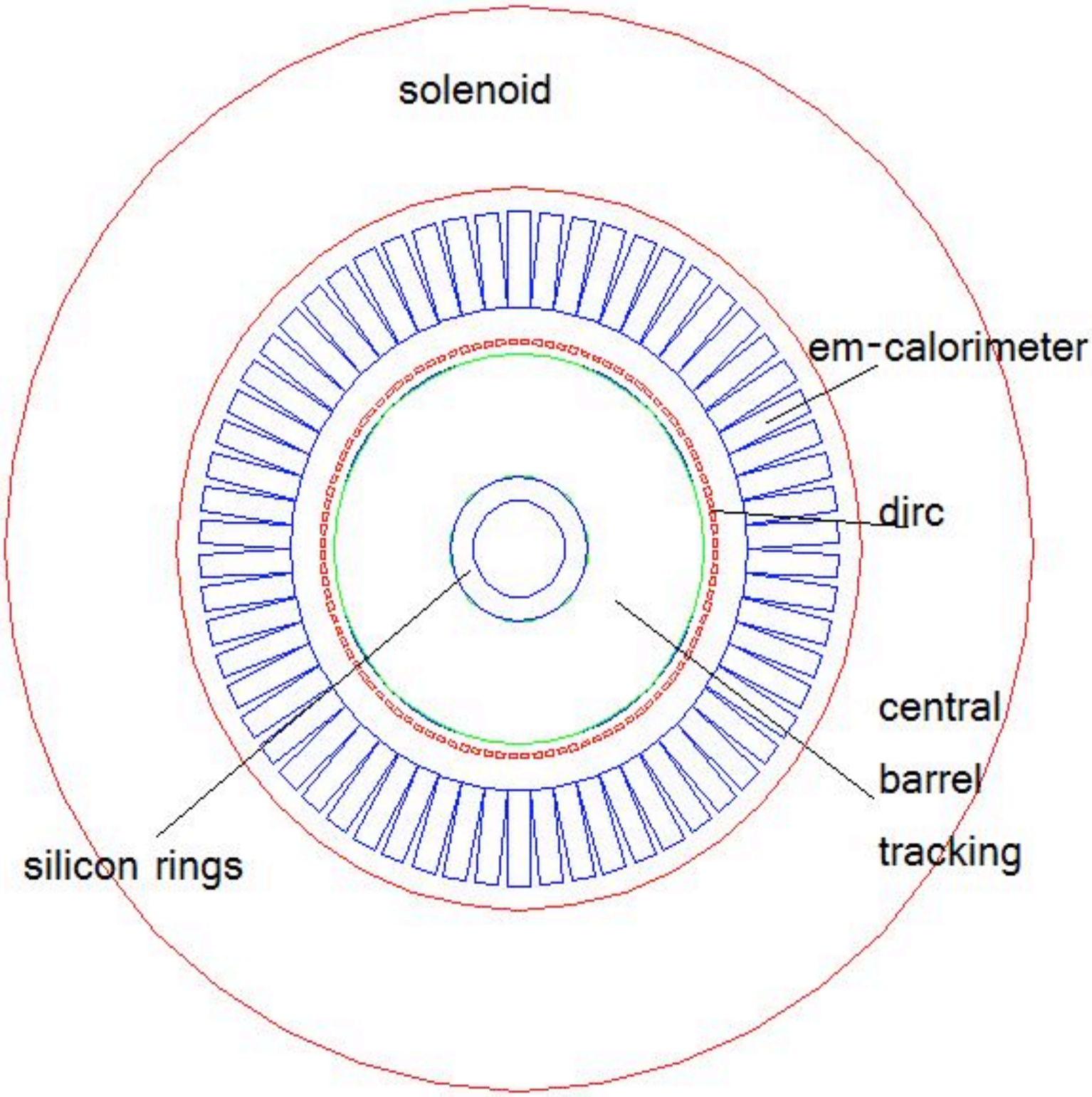

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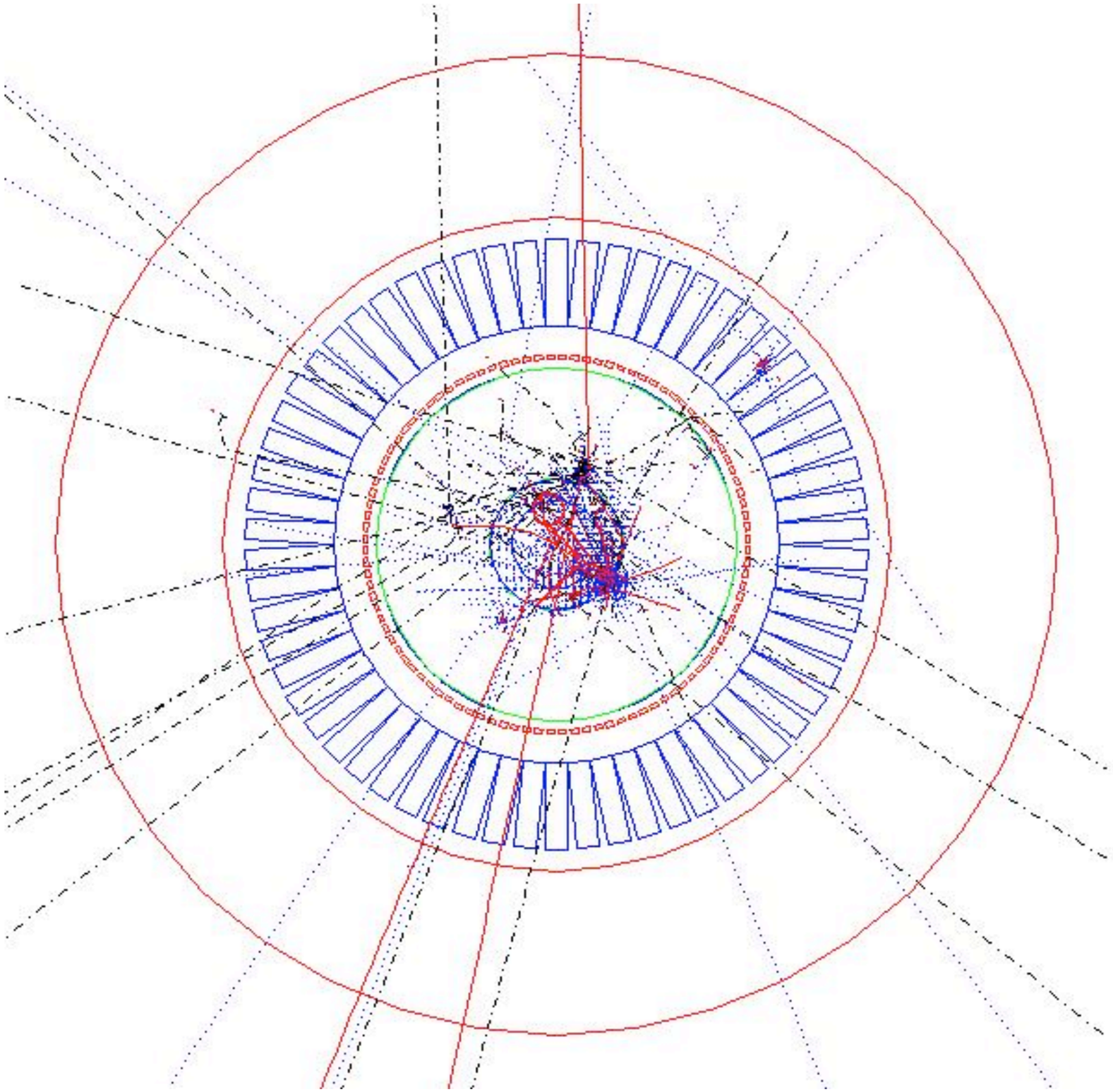
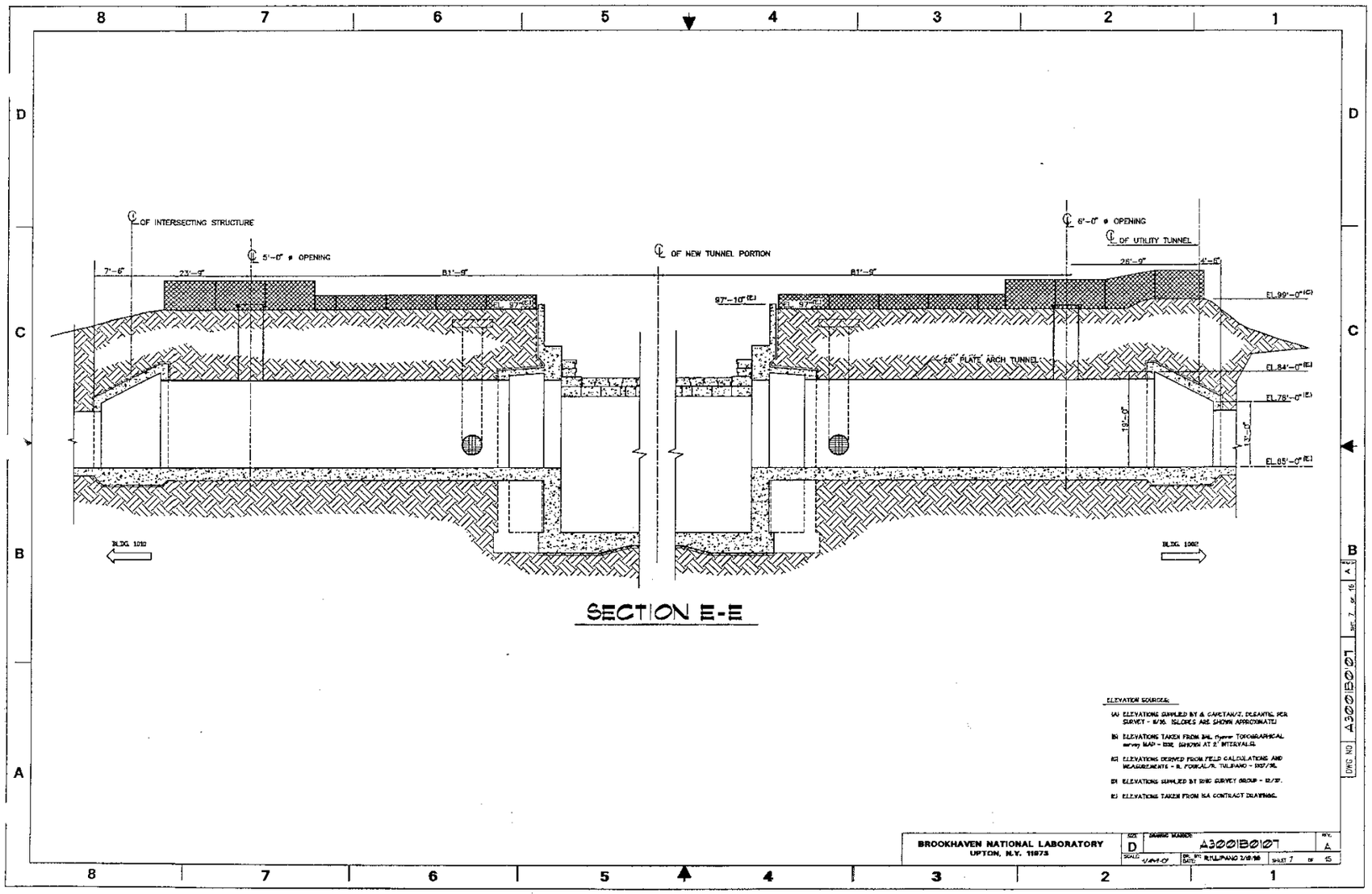


What about 12 o'clock instead of 2 o'clock?

- Detector cost savings
  - ➡ Fully staged detector from MeRHIC to eRHIC
    - Vertical space much greater
    - Need to buy magnets only once
    - Can stage detector components (e.g. hadronic calorimeter)
    - No moving of components



Summary and Outlook

- First steps completed on detector design
- Optimisations still needed
  - ➡ Magnetic fields
    - Do we need a 4 T Solenoid and 3 Tm for the dipole?
  - ➡ What radiation length can we tolerate for low momentum scattered leptons?
  - ➡ Optimize the distance between Solenoid and Dipole
  - ➡ What is the impact of the beamlines through the detector on the physics?
  - ➡ Need to optimise the acceptance at low scattering angles
    - need acceptance down to 1^{o}
  - ➡ Need to add “Roman Pot” detector into geometry
  - ➡ Need to include lepton polarimeter and luminosity monitor into IR design